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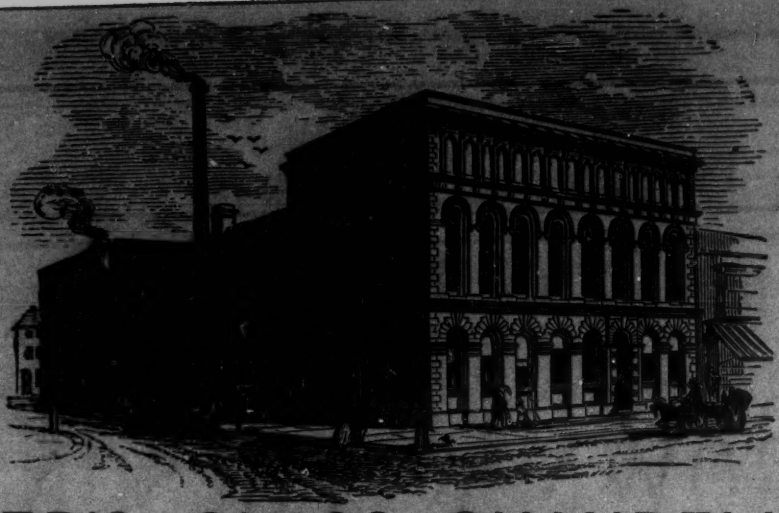

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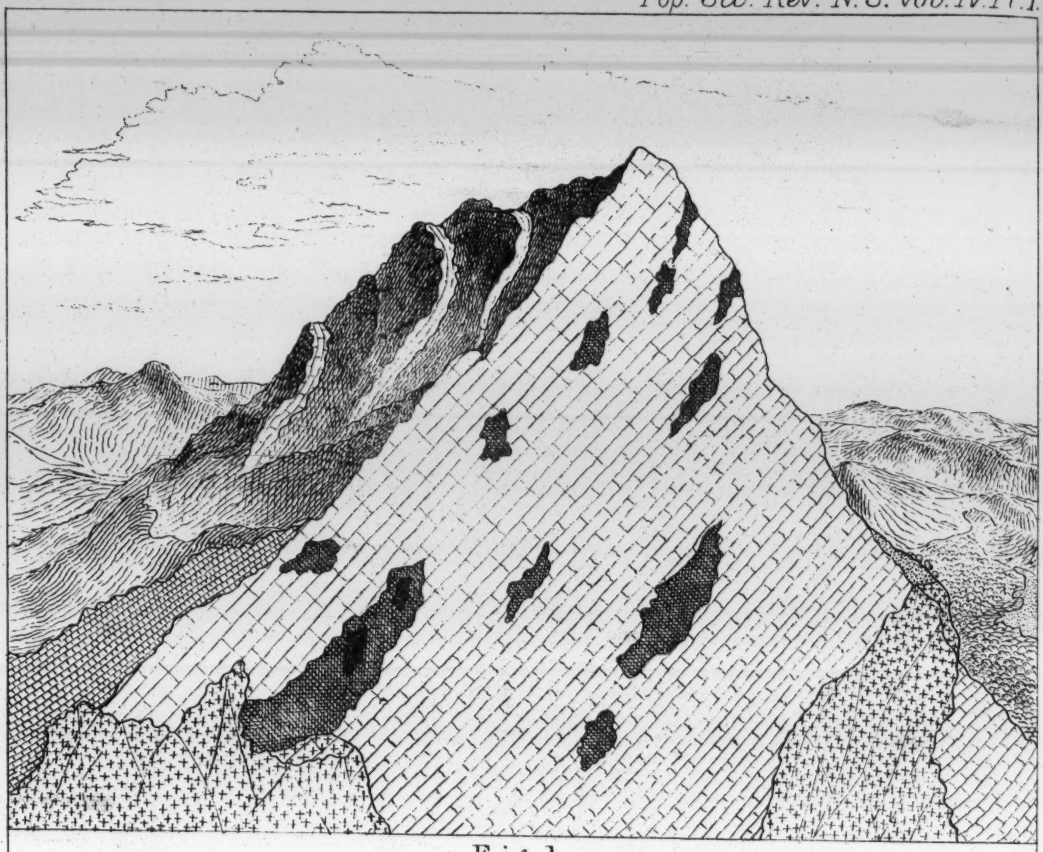
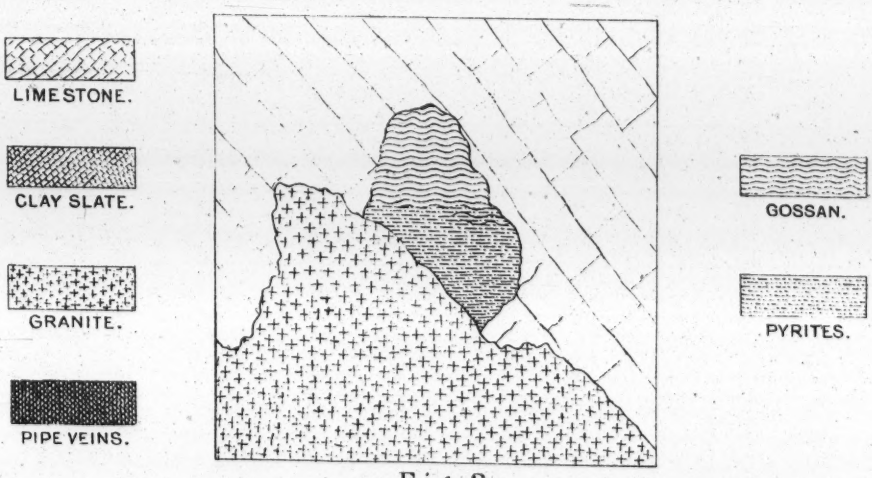


Fig. 1.



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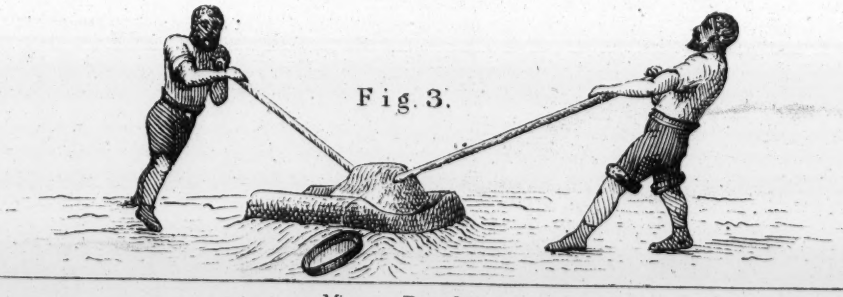

Fig. 3.

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POPULAR SCIENCE REVIEW.

NOTES ON THE ARGENTINE REPUBLIC.

By CHARLES OXLAND.

[Plate I.]

THE immense territory possessed by the Argentine Republic, about 1,152,000 square miles, with a population of only 1,200,000 inhabitants, forcibly recalls a remarkable feature in ancient Spanish colonization. The Spaniards in their expeditions were usually not contented with safely establishing one point only on the sea-coast, but they pressed forward to the interior, making new conquests, and often leaving behind them small garrisons which the Indians required but little provocation to attack. This system frequently led to serious disasters, as is instanced by their chief seaport settlement of Buenos Ayres, which, on account of persistent Indian attacks, was twice abandoned, previous to its final settlement in 1580. The courage of the Spanish settlers was sorely tried, and the history of the country shows that the wide extent over which the Indians have ranged, from the 'Gran Chaco,' or Indian territory of the north, to Patagonia in the south, has been one of the principal causes of the slow development of the interior provinces along the eastern slope of the Andes.

Between Buenos Ayres and Rosario a short distance is now travelled by rail, whence steamers take passengers up the Parana. The variety of scenery and the richness of vegetation on this river make this journey a great treat to the lover of nature; the beautiful bits of tree, shrub, and bank, that open up full of colour and graceful form at each successive bend are almost bewildering, and make one long to have time to absorb the whole scene. In many places the banks of the river are flanked by higher ground, which shows signs of having, at some time, bounded a stream compared to which the present one would be a pigmy in size. The Parana, as it now is, allows steamers of 1500 to 2000 tons to go up to Rosario, a distance of nearly two hundred miles; and navigation for small

craft is possible to a distance of one thousand miles from its mouth.

Rosario, the terminus of the railroad, built immediately on the banks of the river, is only second in importance to Buenos Ayres as a centre for the receipt of the produce of the country intended for export, as also for the distribution of imports. From here the railroad strikes out across the flat country of the Pampas to Villa Maria, from which place one branch runs northwards to Cordova, 245 miles from Rosario, and to Tucuman, 340 miles from that city, and the other towards the south-west as far as Villa de Mercedes, about 190 miles, from which point it is proposed soon to extend it to Mendoza, San Juan, and over the Andes to Chili.

In the run to Villa de Mercedes as well as to Cordova, the rail passes over Pampas largely utilized for grazing cattle; the soil is alluvial, and gravelly in patches, but mainly the former, the alluvium being from two to eight feet in depth, under which lie beds of detritus of great thickness, often more than eighty feet.

Farms are spread out across the country, mainly employed in raising horned cattle, horses and sheep, of which late estimates give about seventeen to eighteen millions of horned cattle, and ninety to ninety-five millions of sheep; the land offers good opportunities in this direction for enterprising and determined men, but great energy is required to manage well during seasons of drought.

The settlers along the line of rail, among whom are included English, Scotch, Irish, French, Germans, and Italians, look healthy, and as though they enjoyed a good climate.

The ride by rail is not particularly interesting, excepting in the opportunity it affords of seeing a great variety of human nature, and of accumulating a weariness of the flatness of the country, which makes one long for a sight of the Sierras, or of the Cordillera. One thing is very striking, namely, that as you pass up the line of rail towards Villa de Mercedes, the number of foreigners becomes gradually less, until at the above terminus they are almost wholly left behind. This may be accounted for from the greater risks incurred in farming in these parts from occasional raids by bands of Indians; the line of military outposts extended across the country to San Rafael, in the province of Mendoza, being here closer to the road.

At Villa de Mercedes, the present terminus of the railroad, the scene changes to one of greater interest, with more numerous chances of adventure. From here coaches ply twice a-week to the mountain provinces. The paper-money of the provinces, off the lines of railroad, is represented by the Bolivian silver half and quarter dollar pieces. This is the

case also with the 'Fuerte,' or enforced national paper, which is not current away from the provincial centres and larger towns.

Villa de Mercedes is a little to the west and south of the Sierra de Cordova, a range chiefly made up of granitic rocks. Travellers here take a conveyance less comfortable than a Californian stage-coach, and more like a light but strong omnibus. The small quantity of luggage allowed free of charge—twenty-five pounds—is packed on the top. Two shaft mules with driver, two other pairs with a gaucho postilion for each, with conductor, seven people inside and three behind the driver, on a sort of box-seat, make the complement. The scenes that occur at a start are often very amusing; the disputes over seats, the anxiety of passengers about their packages and edibles for the road, but more often the capers of half-wild mules when being harnessed. The writer saw one of these animals throw itself completely backwards three times, making it necessary on each occasion to re-harness it, and after the third attempt another was put in its place.

All being ready, the driver, a wiry half-breed, gathers up his reins and cracks his whip, the gauchos tighten the traces, ply their spurs, and away goes the coach at a wild pace, swaying and creaking down the sandy road to the open country, with the conductor executing flourishes on his bugle. The dust and heat detract but little from the freshness of such a scene to an European, especially as the road passes towards rising ground.

After a distance of ten or twelve miles, the bugle sounds long and clearly as we cross some rolling country with occasional trees and shrubs. Suddenly, two men on horseback are seen driving horses for the coach into a roughly-constructed corral, or enclosure, about seventy or eighty feet square, made of brushwood, cut from the country around, and piled some six feet in height. Here again is a lively scene in changing mules for half-wild horses, the passengers the while stretching their legs and smoking. The cigarette forms a wonderful solace to the South American traveller; it whiles away delays, makes a bond of sympathy between people from widely-separated parts of country that may be fellow-passengers, and brings out many a tale of travel and adventure.

The first stopping-place at night is at a curiously wild spot on the borders of the Indian country, a house of one storey, with thick mud or adobe walls, forming one end and part of one side of an enclosure, about a hundred feet by fifty; at the other end of which is a pair of large wooden doors; these are closed at night, and form a protection for coach and passengers.

After an evening meal of soup, followed by an 'assado,' or joint

of meat, cooked over hot embers, a dish often very savoury, with eggs, wine of Mendoza, bread and coffee, all join around the fire for a chat and smoke before going to sleep, which is truly enjoyed on camp beds under a verandah. A large fire burns all night in the middle of the enclosure, exaggerating, by its light, the forms of the gauchos in their coloured ponchos before it, or of the coach and sleepers around; making a strangely picturesque scene.

At daybreak the bugle of the conductor stirs the travellers out of a heavy sleep, to wonder where they are; and after much merriment, and some grumbling at the early start, all rise for coffee, and to make arrangements for breakfast on the road, which quickly passes the time. Away again for the open country, just as the sun is rising, and throwing his first straight rays and long shadows across the wild scene. The road now goes across a country that bears many traces of water action; now over pebbles, then over sand, until some high ground is reached, where the Sierra de San Luis first comes into view. Here the wild verbena is found in its home, and truly beautiful the patches of colour look after the dulness of the scenery left behind. The variety of the shrubs, and their richness of growth, make a fitting foreground to the scene beyond; hills in long undulations stretching as far as the eye can follow towards the west, with the Sierra de San Luis a little to the north and on the right.

This Sierra is a continuation of the line formed by the Sierras de Ullapez and de Los Llanos, stretching away north into the province of La Rioja, made up of schistose metamorphic rocks, granite, and sandstone, carrying large veins of quartz, and rich in metals—copper, lead, gold, silver, and nickel. The little town of San Luis, 3700 inhabitants, stands 2500 feet above the sea, and is at the foot of a picturesque peak rising 2000 feet above it, from the top of which, in clear weather, Aconcagua, 23,000 feet in height, can be seen nearly 200 miles to the west. The people of this province have suffered much from Indian raids and civil war; but among them may be seen many good faces, and they exhibit a dignity of manner that makes a pleasing contrast when compared with the inhabitants of some other parts of the country. Grapes are abundant, and oranges, peaches, and figs, plentiful in season. The climate of the Sierra is said to be good for consumptive patients; that of La Carolina, a town further north, and at an elevation of 4900 feet above the sea, being peculiarly suitable; the temperature here is from 60° to 70° Fahrenheit; the air is dry and bracing, the scenery fine, and good food is procured from the valleys below.

On the road from the Sierra de San Luis to the steppes of

the Andes, but little can be seen of the underlying strata, from their being covered with sand, gravel, and alluvium. On the higher ground, much gneiss and mica schist is found, especially in the Sierra de Las Palomas. The banks of the Rio Desaguadero form an interesting feature; they are composed of micaceous and quartzose sandstones, in some parts with the characteristics of mica schist, and in others crumbling away, probably from weathering, and the action of salts brought down by the waters of the river in its course from the snows of the Andes, across the Lagunas; the banks are from forty to fifty feet in height, and are composed of the micaceous and quartzose matter, which gives to the water its greyish buff colour. From this point to Mendoza, the road passes large farms, or *estancias*, mainly devoted to fattening cattle intended to be sent to Chili. At Rodeo, near to Mendoza, a lively scene may be sometimes witnessed during the shoeing of cattle previous to their journey over the Andes. A shed, set on strong posts against an adobe wall, divides two large yards; looking over the wall near the centre, a good view of the proceedings may be obtained. In a yard about one hundred feet long by fifty wide, with no fittings other than the four walls, a tall brawny gaucho in his many-coloured costume, stands close to a door swinging a lasso over his head; his action is slow and deliberate. Opposite this door, about twenty half-wild cattle are running backwards and forwards the long way of the yard, when suddenly the lasso falls gracefully over the horns of a fine animal; it stops at once; a wild jump and a bellow are the prelude to a rush at the man in front of the doorway, who stands stock still until the animal is within a few yards of him, then with the agility of a kitten he jumps aside. The animal is unable to follow, as whilst he has been coming towards the gaucho, others have quickly shortened up the lasso around a post, which now brings up the furious beast within a few feet of the entrance of the door. Here, catching sight of the men in the shoeing shed through the doorway, he makes a second rush, and is again brought up, powerless, with his head close to a post. His legs are now fastened together by soft hide straps, and with a dexterous throw he is turned over on a bed of straw, and his legs fastened to four upright posts, his head being carefully kept close to a central post whilst he is being quickly shod. We observe that the door by which the animal entered has been closed, and that on the opposite side of the yard, at the foot of the slope, a pond of water, eight or ten feet deep, and twenty feet wide, runs the whole length of a piece of wall, six feet high, and close to the nearest edge. The man who lassoed the animal now stands leaning against the wall; the shoeing being finished all get out of the way, excepting this man near

the water. The lasso is shaken from the animal's horns by a man perched over him in the roof of the shed, which sets him free, more furious than before. Looking round, he sees his old enemy, and at once rushes at him, head down. The gaucho quietly waits until the animal is close to himself and to the water, and then steps behind the wall. The impetus acquired by running down the slope prevents the ox from stopping, and he therefore goes head-foremost into the water, to splash out on the other side, with blood and temper fitly cooled before going to pasture. The animal is prevented from coming out on the same side as the man by a perpendicular bank, while the opposite one is a slope.

On approaching Mendoza distant views of the Andes are seen, and the road is for miles shaded by poplars and willows, growing close to the banks of streams employed for irrigating the farms and pastures.

The waters from the melted snows of the Andes in the Rio de Mendoza, and one of its branches, the Tutumaya, are led considerable distances for irrigation, through channels mostly by the sides of the road, and from these are tapped into the pastures, vineyards, and fields of lucerne, the last of which are protected by adobe walls of four or five feet in height.

The town of Mendoza is beautifully situated, and most picturesque; the views of the Andes to be obtained from several parts of it through streets with trees on either side being very fine, especially when the atmosphere is somewhat clouded, while the ruins of the old town on the same site, 12,000 out of 15,000 inhabitants of whom perished by the earthquake of 1861, renders more impressive the character of the distant peaks.

The waters of the baths gathered from hot springs in this neighbourhood are strongly impregnated with sulphuretted hydrogen and carbonic acid, so strongly as to make their presence recognizable at a distance of a hundred yards.

The generally flat piece of country between Mendoza and San Juan, a distance of eighty-five miles, is interesting in its wildness. The ground shows evidence of the action of water resulting from the storms that sweep over this district, bringing down detritus from the limestone and sandstone hills to the west.

The fine sands deposited in these stream-beds harden and crack into pieces that remain firmly attached to the bottom. This may account for the filling up and diversion of the streams, which has occurred so often, as to have cut up the country in all directions. In passing almost due north from Mendoza to San Juan, the rainfall diminishes, and becomes more uncertain. This may be accounted for, to some extent, by the bend westward taken by the main chain of the Andes. The great Plateau, the western slope, and the Primera

Cadena, or first chain, with the valleys formed by the Cordon de Tontal, Sierra de Zonda, and other smaller parallel ranges, receive more rain or snow than the lower country to the east. This is accounted for by the partiality of summer thunder-storms for the higher ridges and more contracted valleys. One of the most noticeable features of the high ground of the province of San Juan is the clearness of the geological sections, suggesting sudden and severe storms, carrying detritus to great distances; this is further confirmed by the hardy character of the vegetation.

The province of San Juan is situated almost wholly within the outlying spurs of the Andes, and is geologically and socially interesting. The province contains about 60,000 people, a hardy mountain race, who live mainly by farming, wine-growing, and mining. The town of San Juan, the capital, is built on the site of the old river of that name, and has been often flooded by its waters during the melting of the snows. The houses are built of adobe; but some of the public buildings, commercial houses, and private dwellings, are of burnt red brick. Two distinct methods of making these adobe houses are employed. In the first gravel, alluvium, and sand deposited by the river are mixed with water, hammered into a strong wooden framework, held by twisted ropes, about four to six feet long, two to three feet wide, and three feet deep. As soon as one block is finished, the framework is moved on far enough to join the block just completed, one end of the finished block forming one end of the box or frame within which the material is pressed. When one tier has been thus completed the framework is raised, the previous tier forming the bottom; a little moistening of the lower tier secures adherence of the one to the other. On these rough walls two kinds of plaster are laid, one of alluvium and dry mule dung or cut straw, the other of lime plaster or stucco, and on the plaster is laid lime-wash, sometimes coloured blue and buff, with other ornament, according to the means of the occupant. The tops of the houses have a thick layer of alluvium and mule-dung laid on them, and are slightly inclined to carry off rain. And it is surprising how well they keep out the wet. The thick walls further act as a protection against the heat of summer. In the other form of adobe wall, the mixture of gravel and alluvium is made into blocks about eighteen inches long, twelve inches wide, and from six to nine inches thick; these are built up after drying with some of the same mud as mortar. These houses, by the assistance of stucco and the washes of Italian masons, are made much more pleasing in appearance than the roughness of the principal materials would suggest. The domes and towers of churches are covered with blue and white tiles, or are elaborately plastered.

The people here have more of the energy and physique of a mountain race; the dryer climate developing more nervous energy. They have had for seven years a system of compulsory education in operation, and now spend between 11,000*l.* and 12,000*l.* a-year on primary schools; and in the capital they have a national college with eight or nine professors, in which a good course is given in Mathematics, Agriculture, Mining, Metallurgy, Chemistry, Law, and Literature. They have at present one pupil for every seven inhabitants.

The Peon, or labouring class, receive from 23*s.* to 33*s.* per month, with their food, consisting of flour, beef, raisins, and maize, or Indian corn; the quantities varying according to the liberality of the employer. The meat is usually made into a soup with maize, onions, and any other vegetables they can obtain; and the raisins are sometimes used in cakes, or eaten alone. Their main drink is the well-known Maté or Paraguay tea, the dry leaf of a species of holly, the *Ilex paraguayensis*, grown principally in the Republic of that name, and in Brazil. This leaf, generally in a powdered state, is put into a gourd 3 or 4 inches in diameter, from which the inside has been carefully removed, a small quantity of sugar added, hot water poured on the top of the two, and the infusion is then sucked up through a silver or electro-plated tube. This makes a refreshing drink, and has great staying properties without producing the ill effects often ascribed to tea. Wine, though cheap and good, is rarely to be procured by them, and the more expensive *aguardiente*, or brandy distilled from the wine of the country, still more rarely. They are a temperate and industrious class, and when living near the towns often add to their comforts by growing vegetables, cultivating a few vines, and drying the grapes on the tops of their houses. This last makes an important item in the business with other provinces, and with Chili, the raisins being remarkably good.

The wines of San Juan are much like those of Spain, and are free from the overloading of spirit so common in wines sold in this country,

In the pastures of lucerne irrigated by channels taken from the river, large quantities of cattle are fattened; these are bought by the farmers in the adjoining provinces, or raised on the spot, and during the summer and autumn months—there from November to April—are sent to Chili across the Andes, and to Bolivia, 700 or 800 miles to the north. Their fat condition and slow travelling enable these animals to stand the wear of such a journey. Men receiving from 3*l.* to 4*l.* only per month, are sent off in charge of 'tropas,' or herds, of cattle with other men under them at less wages. These sell the cattle, receive the money, and return with it to their

employers, thus showing their trustworthiness when placed in positions of responsibility.

In the future there can be no doubt the province of San Juan will be an important contributor of metals; the principal known mining centres are Tontal, Gualilan, Hilario, La Huerta, Castania, Guachi, Chila, and Salado.

Gualilan, one of these, is situate in a district full of geological interest. The road to it strikes a little to the north-west of the town of San Juan, across the river of that name. This river, made up of the Rio de los Patos and the Rio del Castania, the latter coming through a district in which gneiss, schists, granite, and sandstone abound, furnishes the greater part of the micaceous matter so abundant in the waters of the San Juan. On the northern side of the river, here running nearly due east, is a range of hills, the Sierra de Villagun, composed of limestones and sandstones, with a direction nearly due north and south, and a dip of from 40° to 45° west.

On the eastern side of this range ironstones and bituminous shales are found, and of a northern continuation we shall have occasion to speak subsequently. Imperfect specimens of *Ammonites communis* and *A. Bucklandi* have been found here, and there can be little doubt that we have here the Liassic group of the Jurassic system.

This range of hills, 2500 feet above the river, or 4500 feet above the sea, increases in height, like the limestone ranges west of it, towards the north, and reaches a height of 18,000 feet.

Going again to the north-west, the road crosses a desert about twenty-five or thirty miles to Talacastro, where it goes through a pass in the Sierra de Jachal. Here we meet with a limestone somewhat darker in colour, the formation much the same generally, but the layers of limestone thinner, and dipping west at an angle of 65° in the highest hills, about 1500 feet above the road. The contortions of the strata at the entrance of the pass are very remarkable, but further up the stratification becomes regular and distinct, until we reach some irregular shaly and sandstone beds, in the former of which are found 'gossans' and quartz containing gold and silver, to the amount of 1½ oz. of the former to 2 or 3 oz. of the latter.

From the summit of this pass in the 'Camina de Borros,' (donkey road), the direction of the range of hills in which the Gualilan mining region lies, can be traced away north into the Sierra de Jachal, which rises from a height of 7000 to 16,000 feet above the sea, in a distance of about forty miles. The view from the highest point of this road is extremely beautiful; a sandy desert with a scrub growth around it, and one or two

patches of green where springs and water drainage have made irrigation possible; on its eastern side is the range just described, and on the western side the high ground, 10,000 to 12,000 feet, of the commencement of the Cordon de Tontal. The hills of Gualilan form a loop bending out of and again joining the Cordon de Tontal with an intervening space of thirty-five or forty miles.

These limestone hills stand some 300 to 600 feet above the level of the detritus, and have an average bearing of nearly north and south; the stratification is distinct and regular, dipping towards the west at an angle of 46°; the upper edges stand out sharply against the sky. Against this limestone on the western side, and rising only some sixty or seventy feet above the camp, is clay-slate much split up and weathered. Both this last and the limestone are in many places cut through at right angles by an intrusive, highly siliceous granite; this granite is found up to a height of 300 or 400 feet in the limestone.

The beds of limestone vary in thickness from six inches to four feet, but may average about three feet; the strata are divided in most instances by very thin layers of crystalline carbonate of lime, and at times by sulphate of lime and by a fine powder of amorphous silica. Throughout this limestone are found cavities, called by the natives *cañas* (pipes), or 'pipe-veins,' which pass through and between the strata, as shown in the section, fig. 1, Plate I. The direction varies little from that of the enclosing limestone, but the dip is far from constant. In many places these 'pipes' open into large cavities, one of which was found to be fifty feet long, and fifteen feet wide at its base, rising between the layers of limestone to a height of 120 feet, with a varying width; many of the layers have several pipe-veins opening into them. The large cavities contain decomposed iron pyrites, and quartz carrying gold and silver in about the proportion of one to one and a half ounce of the former to two ounces of the latter, and on the floors or bottoms iron pyrites, zinc-blende, and occasionally galena; the pipe-veins also contain hydrated ferric oxide or gossan, but in less proportion, often as much as half the diameter, varying from two to fifteen feet, being filled with a compact iron pyrites with quartz running through it. The proportion of gold and silver in the gossan and pyrites of the pipe-veins is about the same as in the deposits in the larger cavities.

The quantity of zinc-blende increases as the deposits are explored in depth, say to fifty-four or fifty-six fathoms; galena occurs in small quantities only, and in most instances near the granite, with which it is often mixed; in such cases the granite becomes friable and is easily broken, the thin cracks in

its mass being filled by sulphate of lime, quartz, and hydrated oxide of iron.

The crystalline sulphate of lime, native sulphur, and amorphous silica, which are found in so many places, suggest that highly heated vapours have played an important part in the history of these deposits.

How the cavities were first formed is not apparent, but the suggestion of some geologists that acidulated water may have caused them, receives some colour from the mode of occurrence of granite in varying places. In fig. 2, Plate I., the section of a pipe-vein is shown with the granite forming the lower wall. The surface of the granite, from which the pyrites and oxide of iron can, in many places, be easily separated, looks rounded and slightly decomposed, but the pyrites is compact and firm.

The granite in several places cuts the limestone nearly at right angles, and where this has been the case, large deposits of pyrites and gossan occur. The active agent in the decomposition of pyrites has been moisture, and this action is still going on, as witnessed in pyrites found exposed in the workings. Some of this, where moisture percolating from above has reached it, has crumbled and become oxidized, the action spreading from small nuclei to the mass around.

The Spaniards and their descendants, in working these pipe-veins, both at Gualilan and at Guachi, twenty miles further north, in a continuation of the same formation, only removed the gossans, which would constitute from one-half to two-thirds of the mass, and left the solid pyrites for future workers, who should have the means of separating the sulphur. They extracted the gold and silver from these gossans by crushing the ore between stones, many of which are still found in the districts. These were of the form shown in fig. 3, Plate I. The ore selected by them, a quartzose gossan, was broken down to the size of Barcelona nuts, and placed with a little water on the lower block, a piece of limestone about three feet long and two feet wide, with the centre cut out, so as to leave sides to guide the upper block, or granite muller. Then two men moved the upper block slowly backwards and forwards over the lower one, until the ore became reduced to a powder as fine as flour; a small quantity of mercury was then added, and the grinding again continued until the mercury was supposed to have amalgamated with all the metals. The ground ore and mercury were then removed to shallow wooden pans, and washed by a free use of water; the mercury was again used in this way until it became saturated with amalgam, when the excess of mercury was removed by wringing in a soft piece of skin. The balls of amalgam thus obtained were covered with clay, and

placed in hot embers. This treatment drove off the mercury, and left a small, spongy ball of gold inside the clay coating. This process only extracted a portion of the free gold, as assays of their 'tailings' show 30 per cent only of the gold to have been extracted.

North-east of Gualilan, and on the eastern side of the Sierra de Villagun, at the junction of the beds of the Rio Flanche and Rio Chilca, which carry water during the rainy season only, is situated a remarkable bit of country. The same limestone as that found in the Sierra Villagun is crossed by the road, which then passes over barren hills of shale and sandstone to the edge of the Valley Fertil. In these hills, parallel to another limestone range in the distance, considerable deposits of bituminous shale are found. These shales vary in thickness, from six inches to eight feet, and are imbedded in yellowish grey shale. One deposit, eight feet thick, has been opened by natives in the hope of finding coal, and samples from the depth of 90 feet gave volatile matter and fixed carbon 9·6 per cent, ash, 86·90 per cent. Colour black, lustre bright, and on exposure to the atmosphere the lumps break up into thin, shaly leaflets; the ash of this shale contained gold and silver in all the samples examined, the highest quantity being $1\frac{1}{4}$ ounce of gold, and $1\frac{1}{2}$ ounce of silver per ton. The seams can be traced along the sides of the regularly stratified hills for a considerable distance (say two miles). Close to these seams are found deposits of ironstone, containing 45 per cent of that metal, and very nearly the same proportion of gold and silver as in the ash of the shale. This is a remarkable fact, and becomes still more so, when we find that the gossan from the decomposition of the pyrites in the limestone hills to the west contains the precious metals in almost the same proportion.

There is a deposit of coal at Hilario, in this province, a sample of which gave $11\frac{1}{2}$ per cent of ash. It is found in the sandstone and shaly beds there existing, and is of such a character as to lead to a well-founded hope of the people that they may have a coal of Oolitic age to assist in building up their mining and other industries, and in reducing the expenditure of their scanty store of timber.

EXPLANATION OF PLATE I.

FIG. 1. Diagrammatic section of rocks in the Gualilan district.
FIG. 2. Section of pipe-vein, with granite forming foot-wall.
FIG. 3. Primitive native mill for grinding gold ores.

METEORS AND METEOR SYSTEMS.

By W. F. DENNING, F.R.A.S., F.M.S.

NO department of scientific research has made more rapid progress of late than that relating to the phenomena of meteors. Twenty years ago our knowledge of these bodies was of the most crude, rudimentary character. Few observers had applied themselves diligently to the task of gathering and discussing observations; and though the planetary theory of shooting-stars offered the most reasonable explanation of their appearance, yet it was admitted that the subject was involved in considerable doubt, and presented many points of difficulty. The occasional apparition of brilliant detonating fireballs, the occurrence now and then of remarkable star-showers, the precipitation upon the Earth's surface of stony masses, were facts which could be verified from many independent sources, and they set men thinking to account for the strange and startling freaks of Nature as exhibited in these phenomena. Could such bodies as aerolitic stones fall from the Moon? Could they, after being expelled from the lunar craters, have met with the Earth in her orbit and come so far within her attractive influence as to have been peremptorily drawn to her surface? Could the smaller shooting-stars, often seen on starlight nights, be mere condensations of gaseous compounds in the extreme outer limits of the atmosphere, rendered combustible by unknown processes occurring at certain stages of their formation? * These, and

* Some of the ancient philosophers appear to have formed correct ideas of the astronomical nature of meteors. Humboldt says that Diogenes of Apollonia, who probably belonged to the period intermediate between Anaxagoras and Democritus, expressed the opinion that 'together with the visible stars there move other invisible ones, which are therefore without names. These sometimes fall upon the Earth, and are extinguished, as took place with the star of stone which fell at Ægos Potamoi.' Plutarch, in the *Life of Lysander*, also says, 'Falling stars are not emanations or rejected portions thrown off from the ethereal fire, which when they come into our atmosphere are extinguished after being kindled; they are rather celestial bodies which, having once had an impetus of revolution, fall, or are cast

other questions, came to the fore at first as likely to yield something tangible in the attempted elucidation of the subject, but the materials from which the investigation must be conducted were of the most imperfect, indefinite nature, and there seemed little prospect of a satisfactory solution of the question on such a basis. Records there were, and in abundance, of many exceptionally large meteors and of star-showers; but though the facts were well attested in themselves, the descriptions failed in the most important details. The observers had been startled by the unexpected character of the phenomena, and had given exaggerated accounts of what they had seen. The vivid brightness of a meteor (overpowering the lustre of the stars, and even vieing with the Moon in splendour), the flaming train left in its wake (curling itself up into grotesque shapes as it drifted and died away), the form of the nucleus with its jets and sparks, and the final explosion with the accompanying reverberations, were all portrayed by the enthusiastic observer; but in rare cases only were the really valuable points preserved for investigation. The *direction* of the meteors' flight amongst the stars, and the *duration* of its visibility, were facts of more significance than the mere appearance of such an object, which, though imposing in an extreme degree, was yet useless for calculation of the orbit. That these points were seldom given their due weight by some observers is to be regretted, though it is a matter for congratulation that at the present day men are fully alive to the importance attached to such records.

Heis at Aachen (and later at Münster), in Germany, was the first to devote himself with proper method to the habitual observation of shooting-stars. He was attracted to the subject at a time when our knowledge was meagre in the extreme, entering a path untrodden by any previous observers, and setting an example to those who followed him in the same line of research. His observations soon indicated the existence of a large number of meteor-showers, and showed that the periodical displays of August and November, though unique and specially interesting as furnishing many falling stars at their several epochs, were not by any means the only such systems requiring investigation. He was aided by the contemporary labours of Schmidt at Bonn and Athens, and other assiduous observers, who now began systematically to apply themselves to the work, cataloguing the apparent paths of the meteors visible during their watches, with the ultimate view of comparing them together and deducing the radiant points of the chief showers. Thus the work progressed until Schiaparelli of Milan enunciated

down, to the Earth, and are precipitated, not only on inhabited countries, but also and in greater numbers, beyond these, into the great sea, so that they remain concealed.'

his theory of identity in cometic and meteoric orbits. He was led to this remarkable discovery by investigations of the August meteors in 1866; and it at once raised this branch of astronomy to a much higher position than it had formerly occupied, for it gave the phenomena of shooting-stars a significance far beyond what had been accorded to them. They were shown to be purely astronomical in nature and origin, revolving in elliptical orbits about the Sun, and existing in infinite numbers in interstellar space. The constituent atoms of a shower became visible when upon the intersection of the Earth and meteor orbit they entered the atmosphere with such velocity as to produce instantaneous ignition and combustion, resulting in the immediate disruption and collapse of each particle so entering into collision. Only in rare cases and in the instance of the more massive fragments would one be found of sufficient solidity to penetrate completely through the atmosphere and fall upon the Earth. By far the greater number of such bodies being of miniature size were consumed in the upper rarefied limits of the atmosphere, and obviously that would be an exceptional incident in which a meteor overcame the resistance of the dense air strata lying closely over the surface of the Earth.

The intimate relation of comets and meteors being clearly demonstrated by their accordant orbits and by the occurrence of star-showers at the very times when the Earth passed through cometary tracks, it was sought to establish the theory on the basis of a large number of such agreements. But apart from the meteoric displays of April 20, August 10, November 13 and 27, there are no instances, which can be safely and certainly accepted, of exact coincidence in the calculated orbits of meteors and comets; and this is a little surprising when we admit into the comparison the large number of results which have accumulated. In many cases the positions of the radiant points agree closely, but the shower of meteors appears to be diffused over a long period, with no evidence of condensation on the special night when the Earth approaches the node. Take the case of Comet I. 1850 ♂, radiant point at 313°·5+60°·5 on June 23+. Now there has never been observed a well-defined outburst of meteors on or about that date, though from the point mentioned a lingering shower (or series of showers) is sustained during the long interval from April to November with an average radiant at 315°·5 + 60°·0, derived from twenty-three independent observations. Another instance of like nature is afforded by Comet II. 1850 ♂, radiant at 2°+54° Oct. 19+, which falls very near a series of showers near *a Cassiopeiæ* at 7°·2 + 52°·1 July—Nov. (twenty-two observations). Now the inference of physical connexion between these pairs of radiant points is rendered untenable by the remarkable persistency of the

meteoric display; for a true cometary shower can only endure a few nights. The agreements, therefore, are conjectured to result from pure accident, for obviously there must arise many similar positions amongst the large number of radiant points at present comparable. This is rendered still more probable by the fact, that even in some cases where the accordance is good, both in position and epoch of the radiant centre, the comet's paths were very distant from the Earth, never approaching it within many millions of miles, so that it is difficult to understand how the particles are encountered at such remote distances from the nucleus. A shower of meteors from *Corona* in April was found to coincide with the radiant point of the Great Comet of 1847; but the accordance is otherwise defective and vitiated by the fact that the comet's nucleus 'in its node and perihelion almost grazed the body of the Sun: and only the lengthy tail which it swept or wheeled round with it can be supposed to have reached the orbit of the Earth.'* Numerous other instances might be cited in which the orbits of comets falling far within the Earth's path cannot possibly occasion a meteor-shower, unless, as Weiss and Schiaparelli have considered likely, 'some portions of the cometary substance, repelled from their proper orbits by the Sun in the form of the tail and other luminous appendages emitted by the comets near their perihelion passages, may have extended to such a distance in their orbit planes as to intersect the orbit of the Earth.'† We are ignorant at present of all the conditions under which meteor-showers are produced, and of the many varieties existing among them; but it appears probable that the meteoric particles may be sometimes distributed over a considerable width of orbit by the trains and other luminous projections from comets during their circumsolar passages.

The apparent long duration of meteor radiant points has struck nearly every observer who has entered fully into this department. Mr. Greg has pointed out, that according to his own experience, the average duration is far beyond the limits considered probable.‡ He states that in his own catalogue of meteor-showers deduced from 2000 shooting-stars seen in England during the years 1849–67 the average duration for forty radiant points (occurring at all periods of the year) is thirty-three days; and there are twelve showers reaching fifty-four days, some of which, however, he regards as not really one shower. He found that in not a few cases the period would seem to extend for two or three months without any special intermission. Dr. Schmidt's results confirm Mr. Greg's, for of the forty-five showers included in his catalogue the mean

* *B. A. Report on Luminous Meteors*, 1877, p. 165. † Id. 1873, p. 402.
‡ *Monthly Notices R.A.S.*, vol. xxxviii., p. 351.

duration of visibility is thirty days or more, and many instances of long duration are similarly evident amongst the extensive observations of the late Professor Heis. Schiaparelli from the reduction of the meteors seen by Zezioli at Bergamo in Italy found a series of radiants in the month of January grouped together near η—ζ *Ursæ Majoris*, and α *Coronæ*—α *Boötis*, and in April near π *Herculis*, and he regarded them as distinct or separate families of radiant points, which, though separated from each other in position or by nights on which no intermediate meteors were observed, nevertheless possessed in common some features of very close resemblance. 'Should the effect of planetary perturbations which retarded the return of Halley's Comet in the year 1759, nearly one month from the time of its perihelion passage, as calculated by D'Alembert and Clairaut, also explain the wide differences between the separate coils of spiral meteoric streams apparently encountered by the Earth in the meteor-systems of which the above groups or families of radiant points appear to present unmistakable examples, a new field of investigation in meteoric astronomy is beginning to unfold itself in these interesting discoveries.' *

In the spring of 1876, the writer commenced a series of observations of shooting stars, and they have been continued to the present time. The aggregate number of meteors observed is 5706, in about 520 hours of watching. The path-directions were always registered with special care, the chief aim being to derive the radiant points accurately. About half of the total number of meteors were recorded before midnight, and the remaining half in the morning hours. To supplement and confirm my personal observations, I undertook the reduction of a large number of the meteor-paths registered in the foreign catalogues of Heis, Weiss, Zezioli, Konkoly, and of the Italian Meteoric Association, 1872, and the number thus projected on star-charts amounts to more than 13,000. A considerable list of radiant points has been founded on this investigation, and the results, when compared with other observations, present many satisfactory accordances. The long duration of certain showers appears to be incontestably proved, for the same radiant points became manifested again and again. They cannot be distinct streams, supplementing or succeeding each other at short intervals from the same general directions, or they would exhibit considerable differences in position; whereas, in the cases referred to, the place of departure adheres tenaciously to the same exact point of the heavens, so far as it is possible for careful and prolonged observations to discriminate. The following are some of the most prominent examples of these long-enduring streams, the average centres of which are derived from a variety

* *B. A. Report*, 1871, p. 48.

of independent determinations by myself and many other observers confirming each other very exactly:—

No.	Apparent duration of the Radiant Point.	Position of Radiant Point. R. A.	Decl.	No. of Radiants averaged.	Approximate Star.
I.	July—Nov.	7°·2	+ 52°·1	22	α Cassiopeiæ.
II.	July 21—Nov. 13	7·7	+ 35·9	14	μ Andromedæ.
III.	July—Mar.	30·2	+ 36·0	20	β Trianguli.
IV.	Aug. 3—Nov. 13	43·9	+ 25·1	13	ε Arietis.
V.	July 6—Dec.	46·2	+ 45·9	22	α Persei.
VI.	Aug. 6—Nov. 12	61·2	+ 36·4	16	ε Persei.
VII.	July 25—Dec. 6	62·0	+ 48·0	12	μ Persei.
VIII.	July 25—Dec. 8	69·5	+ 65·2	10	c Camelopardi.
IX.	Aug. 6—Dec. 27	76·1	+ 32·2	19	β Tauri.
X.	Aug. 29—Dec.	80·4	+ 22·7	14	ζ Tauri.
XI.	Sept. 15—Jan.	106·1	+ 11·9	13	β Canis Min.
XII.	Sept.—Dec.	108·5	+ 24·2	15	δ Geminorum.
XIII.	Sept.—Feb.	132·3	+ 46·9	21	χ Ursæ Maj.
XIV.	Oct. 11—Feb. 16	132·5	+ 20·8	11	δ Cancri.
XV.	Nov. 1—April 12	181·1	+ 34·7	15	γ Comæ.
XVI.	April 21—Dec.	282·7	+ 57·9	21	o Draconis.
XVII.	July 26—Oct. 31	290·6	+ 69·7	14	δ Draconis.
XVIII.	April 19—Nov. 15	315·5	+ 60·0	23	α Cephei.
XIX.	June—Oct.	332·8	+ 48·6	17	Lacerta.
XX.	June—Dec.	335·7	+ 62·7	17	ξ Cephei.

These average positions each represent the focus of a series of well-defined meteor-showers, clustering near together at successive epochs. The following diagram shows, in two cases, (Nos. III. and V.), the individual radiants from which they are derived, which may be taken as fair samples of the whole:—

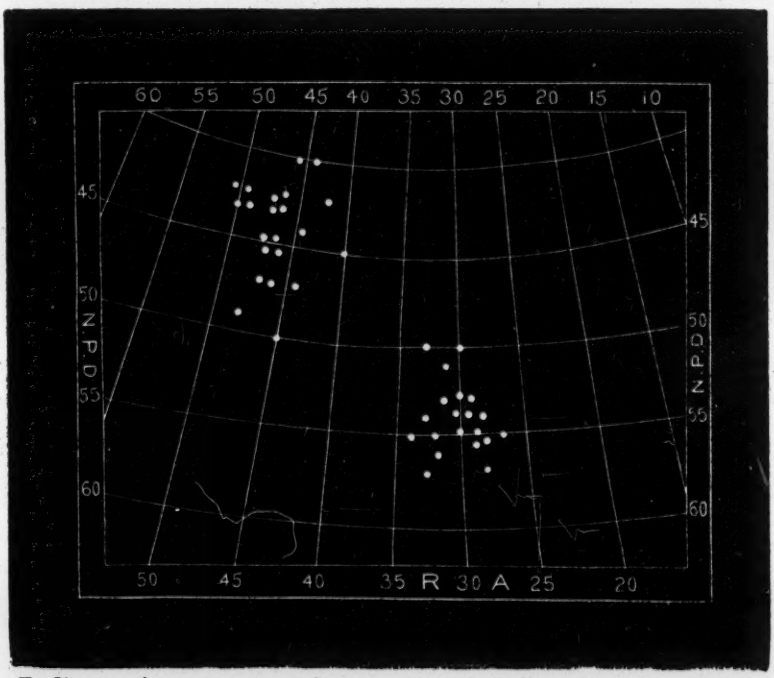

FIG. 1. Radiant points of meteor-showers near β Trianguli and α Persei (30°·2 +36°·0 and 46°·2+45°·9).

The shower, No. III., near β *Trianguli*, is 1½° N. of that star, and nearly all the meteors diverging from it have been short, appearing amongst the well-known stars of *Perseus*, *Auriga*, and *Andromeda*. At first they are very swift, streak-leaving meteors, but at each later manifestation the velocity decreases, and they are rarely accompanied by streaks. It is a remarkable fact, that though I have seen 4400 meteors (exclusive of the August *Perseids*) during the last six months of the years 1876–79, nearly all of them amongst the constellations included in the zone from *Pegasus—Lacerta* to *Leo—Ursa*, yet I have never found a meteor-shower precisely at β *Trianguli*, or slightly below that star, or to the east or west of it. Over and over again the radiant point reappears at the same place, so far as the necessarily approximate nature of the observations will allow one to determine. From *Auriga*, too, the meteors constantly fall from a centre about 2° E of a line joining β *Tauri* and ι *Aurigæ*,* and below an elongated group of small small stars there. (See No. IX.) In *Perseus* there are also several well-determined points of departure extending over a few months; and it now remains for observers to further investigate the alleged peculiarities. The importance of the subject cannot be over-estimated. It is impossible that meteor-showers can last longer than a few nights (except under special conditions), on the assumption that they form parabolic orbits, and that the true cometary-meteor-showers of August 10, November 13 and 27, &c., are to be accepted as typical streams belonging to the solar system. Unless the meteor-rings are of great width, or unless their orbital directions are nearly parallel with the Earth's motion, it is certain that the showers must be very short-lived, because the Earth's orbital velocity of about 18½ miles per second carries her on about 1½ million of miles in a day, and she must quickly traverse the stream intercepting her path, unless, indeed, it is diffused over a vast area of space, in which case the showers might possibly be sustained several months, but not without a change in the position of the radiant point. Evidently the identity of a comet with a star-shower is only safely to be inferred when the position and epochs of the two radiants are in exact conformity. Amongst the very large number of such systems existing in space, there must be many varieties of orbit and origin, and the complicated effect of planetary perturbations upon such slender streams is perhaps not yet sufficiently known or appreciated in its full significance. Towards the ultimate explanation of such anomalies as observations have induced, we require much further assiduous labour in the same field.

Those who have worked in this department of astronomy will

* There is an equally persistent centre 25° N. of this at 77° + 57°.

already understand how extremely difficult it is to obtain accurate and certain results. The infinite number of meteor-streams, and their great feebleness in general, and the difficulty of avoiding error in recording the path-directions of shooting-stars, and ascribing them their true radiants, all render the subject very complicated, and are a source of constant embarrassment to the observer. Moreover, the frequent impediments offered by cloudy weather and moonlight prevent anything like extensive observations being obtained during a single year, though a person constantly on the alert for all available opportunities ought certainly to register between 4000 and 5000 meteors in the course of twelve months, presuming that he worked all night long, and that the period of his observations was ordinarily favourable in point of weather. But extensive work of this kind is almost useless, unless it is thoroughly reliable. Even slight errors in mapping the meteor-paths bring about great discordances, and introduce confusion into a subject the nature of which is confused. The radiant points, deduced from hastily-gathered materials, appear to be extended over considerable areas of the sky, and cannot be determined with the necessary precision. It is a good plan, and one likely to conduce to correct results in observing meteor-flights, to project a perfectly straight rod or wand (held in the hand for the purpose) upon the apparent course of a meteor directly it is seen, and then, noting the path exactly, it may be transferred to the star-chart. By this method the true direction is very closely represented, and it is necessary to adopt some such means of aiding the eye, which often fails to retain more than an approximate idea of the apparent course amongst the stars. The proposed plan so far facilitates precision, that in the case of swift, streak-leaving meteors the paths may often be registered with instrumental exactness, for in the moment that the streak lingers on the course, the wand is projected upon it, and the line of flight carefully noted and accurately reproduced on the star-map.

It is only by the exercise of the utmost attainable accuracy that the numerous distinct showers visible every night of the year may be disconnected from each other, and their radiation-centres ascertained. Observations continued all night, or during at least four or five hours, are very valuable in this connexion; for the majority of the showers are of such extreme tenuity, that during a short watch of, say two hours, no sign of their operation may be evident. It is to long-continued and accurate observations that we must look for important results, and for the final solution of the difficulty presented by the apparent long endurance of meteor-showers. Records of stationary meteors (*i. e.*, meteors whose direction of motion

coincides with the line of sight) are also of great utility, as they obviously appear in the immediate region of the radiant point. Large meteors, such as bolides and fireballs, when observed at several different stations, offer another means of deriving true radiant points, though it is not often that the descriptions of those who witness such brilliant objects are found to agree and to admit of satisfactory comparison. But when, as occasionally happens, the phenomenon is independently recorded by several practised observers, the orbital elements may sometimes be derived with similar accuracy to those of a well-observed comet. The radiant points of large meteors thus derived are strictly comparable with the ordinary feeble showers of small shooting-stars, because there is no doubt they proceed from identical systems. The *Perseids* of August, and the *Leonids* of November, supply meteors of all magnitudes, from the faintest class just within the limits of vision up to the largest type of fireballs. Numerous other systems, amongst which may be mentioned the November *Taurids*, also display the same variety in the brilliancy of their members. The great detonating fireball of November 23, 1877, whose radiant point was very exactly defined (by five good descriptions of the line of flight) in *Taurus* at 62° + 21° belonged to the system of *Taurids* noted by Mr. Greg as a conspicuous shower in November, and well seen by the writer on November 20, 1876, at the point 62° + 22½°. The large detonating meteor seen in the early evening of November 21, 1865, with a radiant point at 56° + 13° appears also to have belonged to the same stream. The great fireball of May 12, 1878, nearly coincided in its radiant point (214° − 7°) with a well-determined radiant at 207° − 8° in April—May; and on August 11, 1876, a large meteor was seen at many places, the recorded paths indicating a good radiant point at 60° + 51°, corresponding with a shower traced by the writer at 60° + 50° on August 12, 1877. Many other corroborative radiants of large fireballs, with ordinary star-showers, might be adduced to confirm the idea that they belong to the same individual systems, though in some cases, it must be admitted, the agreements may be accidental. Prof. von Niessl regards detonating and aerolitic meteors as a distinct class of cosmical bodies, which differ from comets and periodical meteor-showers in the original velocities with which they enter the sphere of the Sun's attraction. He has assigned hyperbolic elements to the orbits of several fireballs, and expresses his conviction that they have native velocities in space bringing them from remote star-spheres into the neighbourhood of the solar system.*

It is fair to conjecture that, amongst the vast assemblage of

* *B. A. Report*, 1877, p. 146.

meteor-streams annually intersected by the Earth, there are many varieties of orbit, from the hyperbola to the nearly circular orbit, calculated for the fireball of Nov. 27, 1877, by Major Tupman. The observed time of flight is the important element in the determination of meteoric orbits; and it is unfortunate that accuracy is very seldom attained in this respect, and that sufficient attention is rarely given by observers to the estimation of a meteor's visible duration. As to the number of meteor-showers at present ascertained, it is impossible to specify the exact figures. Several hundreds of well-defined systems are now included in our catalogues, and this department is enriched every year with new additions to its already extensive records. Previously unsuspected showers are constantly being brought to light by assiduous observations; new meteor-epochs of decided intensity are becoming well established; and many of the old showers receive frequent and ample confirmation during their annual recurrences. But though much has been achieved, more remains to be done in the future, for we are only just beginning to unravel the complicated details of the subject. Meteoric astronomy is but in its infancy. While other departments of Science can number their centuries of research, this branch can only go back a few years to the time when Heis first gathered the materials for its primitive elucidation, and the subject is so wide and difficult, requiring ages of diligent observation to explain the intricate and anomalous points it opens up for investigation, that it will be very long before we obtain a full knowledge of the principal meteor-swarms in their varied aspects, for they are as numerous as the stars in the sky; and the extremely feeble nature of their apparition will for many years enable most of them to elude detection. The intermittent character of the true periodical showers will also allow them in some cases to escape the most vigilant eye, for becoming visible at very short intervals only once or twice in a long period of years they are very likely to be overlooked, though their special intensity will generally afford the means of their discovery.

Meteors proceeding from the same stream present great similarity in their visible appearances, and if the observer is careful to note this in the case of each meteor seen, he will often be able to attribute the true radiant point though the path may be directed from the positions of several contemporary showers. Thus the *Perseids* of August 10 and the *Leonids* of November 13 are of great swiftness, frequently bright, and with the almost invariable accompaniment of streaks. The *Orionids* of October 20 are of the same character. The *Geminids* of December 10–12 are swift, short meteors without streaks. The *Taurids* of November are slow, sometimes trained, and

often brilliant; and in the early evenings of that month, when the radiant is at a low altitude, they are extremely conspicuous objects with inordinately long courses. The *Andromedes* of November 27 are very slow meteors, and not so brilliant generally as the *Perseids* and *Leonids*. In fact, the two great showers of November are utterly dissimilar in many points, though each can boast a parent comet, and each can give a periodical display of exceptional grandeur.

It must be remembered that the appearance of meteors is a good deal affected by the position of the radiant points, astronomically and sensibly. Showers directed from the neighbourhood of the Earth's apex are characterized by great swiftness and enduring streaks, but the non-apical meteors are of less speed, according as they recede from the apex, and phosphorescent streaks are rarely seen upon their courses. The position of a shower sensibly, and often materially, modifies the distinctive features of its members. When the radiant is on the horizon, the apparent paths are of extreme length; but a radiant at great altitude, near the zenith, will furnish meteors with short, diving courses. These changes are due to the effects of perspective, and it is evident therefore that observers should carefully regard these facts in determining the real diverging centres of showers, for during the same night the meteors of one family undergo striking variations as the sensible position of the radiant alters its situation with respect to the observer's horizon. This will become apparent at once if the *Leonids* are watched from their rising on the night of November 13. At first the conforming meteors are of considerable length, and their flights are somewhat gradual across the sky; but just before daylight, when the stars of *Leo* are approaching the meridian, their short, darting courses are in singular contrast to the earlier apparitions. When the radiant is very low, the visible paths are occasionally extended over a vast space of the heavens. On November 12, 1879, at 10.17 p.m., the writer observed a *Leonid* (though the constellation of *Leo* was below the horizon) with a path of 98°, and this, with a single exception, was the longest track ever recorded by him. On December 13, 1876, a meteor was seen at $7^h\ 28^m$ p.m. with a path of 122° directed from a shower in *Leo Minor* just rising. The average lengths of meteor-paths would appear to be about 11°. The mean assigned by Coulvier-Gravier is 13°·9. Schiaparelli deduced from Tupman's observations an average of 11°·0. The writer at Bristol finds 11°·23 from his own observations,* and Sawyer at Boston, Mass., gives 9°·8.

But the mean apparent *lengths* of the paths are of minor importance to the *directions* of the paths, and it is to be hoped

* Deduced from 3203 meteor tracks registered in 1876-78. Of 661 tracks since recorded n 1879, the mean length is 11°·34.

that at some future time when such records have multiplied an attempt will be made at a complete reduction, with the idea of distinguishing the showers common to each night of the year. We have already gathered a sufficiency of materials for certain periods, viz., April 18–20, July 25–31, August 5–12, October 18–22, November 10–13, &c., when observers have been diligently watching the occurrence of the special showers of those epochs. In August particularly a large number of records have accumulated, and chiefly on the few nights when the *Perseids* offer an abundant display; in fact, about two-fifths of the aggregate mass of shooting-star observations are for this period alone, and it is now important that the work should be more equally distributed over the year. Many nights have been almost wholly neglected, and many suspected showers have received meagre support. The more slenderly ascertained epochs now demand investigation, equally with those already well-authenticated by numerous observations.

Certain nights of the year show a marked predominance of fireballs and meteors of the brilliant class. The writer recently tabulated about 3600 such observations with the view of finding the special dates of frequency, which were indicated as follows:*

January **2**, 21, 31.
February 3, **7**, 10.
March 1, 2, 4.
April **11–12**, **19–20**.
May 2, 4, 15, 31.
June **6**–7, 12, 29–30.
July 11, 20–21, **25–30**.
August 3, 5, **7–13**, 15, 19–22.
September **1–2**, **6–7**, 11–13, 25.
October 13, 15, 17–18, 22, 24, 29.
Nov. **1–2**, 4, **6**–9, **11–15**, **19**, **27**.
December **8**–9, **11–12**, **21**.

The most remarkable of these dates are distinguished by larger type; they agree in many instances with the epochs of prominent meteor-showers.

From the extensive lists of radiant points published during the last few years, it is difficult to select those positions offering the most abundant displays; but it is believed that the following table (necessarily very incomplete) includes the chief showers observed or reduced by the writer during the last few years.

Epoch.	R. A.	Decl.	Epoch.	R. A.	Decl.
Jan. 1	230°	+ 51*	Mar. 14	263°	+ 48°
Jan. 9 and Dec. 10–13	221	+ 41	April 9–12	212	+ 65
			April 9–12	184	+ 59
Jan. 14	130	+ 44	April 19–20	274	+ 37*
Jan. 17	295	+ 53	April 19–23	288	+ 22
Feb. 15–20	236	+ 11	April 19–23	295	+ 42
Feb. 20	181	+ 34	April 19–23	280	+ 58
Feb. 20	263	+ 36	April–May	229	− 4
Mar.	175	+ 10	May	210	− 10
Mar. 14 and April 9–12	249	+ 51	July 11, 25–31, and Aug. 10	6	+ 37

* *The Observatory*, vol. iii. pp. 127–32.

Epoch.	R.A.	Decl.
July 27–30 & Aug.	341°	− 13°*
July 28–30	326	− 12°*
July 30—Aug. 1	32	+ 53°*
July 29 and Aug. 4 and Sept. 14–15	30	+ 36
Aug. 6–13	96	+ 71
Aug. 6–12 and Nov.	70	+ 65
Aug. 6–12 and Sept.	61	+ 39
Aug. 6–12	61	+ 48
Aug. 6–12	78	+ 56
Aug. 10	43	+ 58°*
Aug. 12	31	+ 18
Aug. 21–23	291	+ 60
Sept. 1	306	+ 54
Sept. 21	31	+ 19
Sept.–Oct.	78	+ 57
Oct. 2	225	+ 52
Oct. 3–4	133	+ 79
Oct. 8 and 15	46	+ 27
Sept. 14–25 & Oct. 8 and Nov. 7	77	+ 31
Oct. 8	103°	+ 12°
Oct. 15	133	+ 20
Oct. 15–16	31	+ 9
Oct. 15–22	92	+ 16°*
Oct. 15 & 30	108	+ 23
Oct. 31—Nov. 4	43	+ 22
Oct. 14–20	106	+ 50
Oct.	316	+ 59
Oct. 17–19		
Nov. 7	102	+ 72
Nov. 8, 12, & 20	62	+ 22°*
Nov. 13	148	+ 23°*
Nov. 26–29	155	+ 36
Nov. 26	208	+ 43
Nov. 27	29	+ 46°*
Dec. 6	80	+ 23°*
Dec. 8	145	+ 7
Dec. 9–12	106	+ 32°*
Dec. 9–12	134	+ 50
Dec. 9–12	152	+ 43

An asterisk is affixed to the major showers, though it is impossible to say in several cases, which of them are entitled to precedence.

The two oldest, and certainly the most notable, of the meteor-systems of which we are at present cognizant are those of August 10 (*Perseids*) and Nov. 13 (*Leonids*). And since the magnificent star-shower of Nov. 27, 1872, we have a third specially interesting system, remarkable not only on account of its unrivalled intensity, but also on account of its probable identity with Biela's lost comet, of which it apparently forms the *débris*. Repeated search for the comet has been fruitless since 1852, and this meteor-stream occurring at the end of November, and obviously following the same orbit, is the only indication we have of its present existence. As to the shower of *Perseids* in August they form the meteor-flight of Comet III. 1862: and the *Leonids* of November present an orbital resemblance to Comet I. 1866. The former shower recurs annually with considerable activity, supplying about sixty meteors per hour (for one observer) on the night of the maximum intensity, so that the particles must be scattered pretty evenly along the orbit. But in the case of the two November streams the conditions are different. The atoms are evidently condensed about the regions of the cometary nuclei, and it is only at certain epochs (when the comets are near their nodal passages) that a rich display can be expected. The *Leonids* were seen by Humboldt in 1799 on November 12; and in the years 1833 and 1866 they reappeared with striking magnificence, so that the periodical apparitions are due at intervals of $33\frac{1}{4}$ years, and may

be next expected in 1899. But there is no doubt that though this meteor-cloud is confined in its main richness to the close region of its cometary nucleus, yet the particles are sparsely dispersed through the whole orbit. The stream may be very attenuated in places, but careful observations sustained at the proper time will reveal a few of the swift, streak-leaving meteors incontestably belonging to this shower. There were displays in 1787, 1818, 1822, 1823, 1841, and 1846, and more recently in 1877 and 1879, though in each case the comet itself was far removed from the neighbourhood of the Earth's orbit.

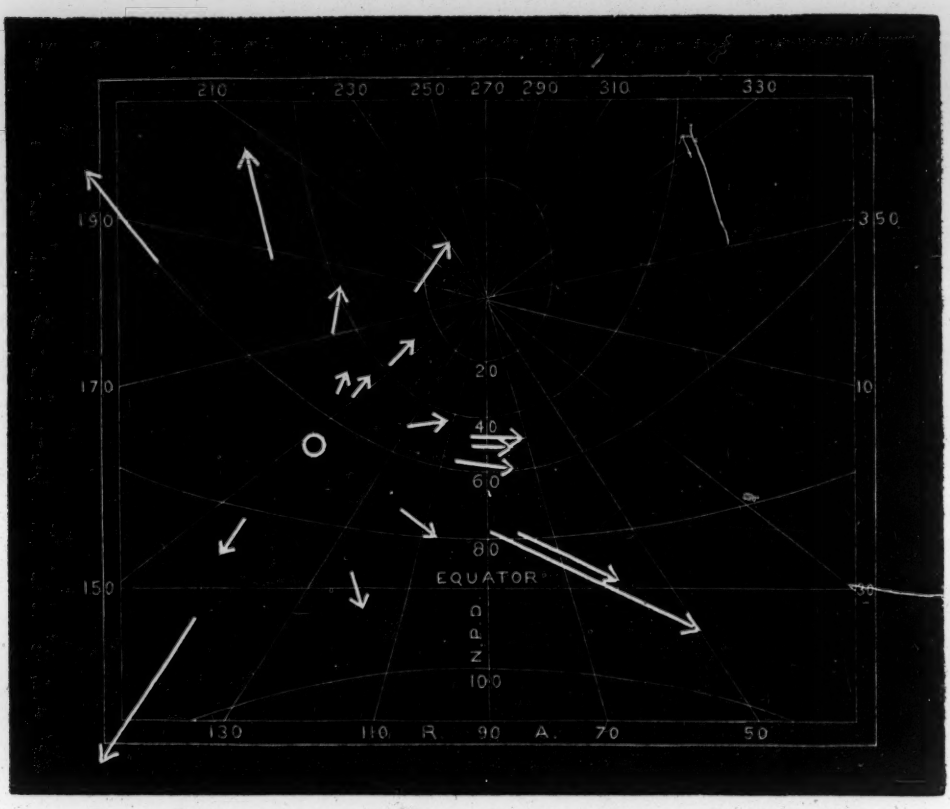

FIG. 2. Paths of 17 *Leonids* observed on the morning of Nov. 14, 1879. Radiant point = 148° + 23°.

The shower of the present year was sustained over the five nights from Nov. 11 to Nov. 15. The first meteor was seen at about $11^h\ 31^m$ on the 11th, both at Greenwich and at Writtle, leaving a fine streak amongst the stars in *Eridanus* and *Cetus;* but the paths as registered at the two stations are non-divergent, and the radiant cannot therefore be derived with certainty, though the meteor was undoubtedly a brilliant *Leonid.* On Nov. 12, Mr. H. Corder, at Writtle, in Essex, saw many meteors (in a watch of five hours), including twelve from a good centre in *Leo* at 149°+23°, and on several other nights he traced additional paths, making 29 in all, from

the same system. They were bright meteors, eight of them appearing equal to stars of the first magnitude, and eighteen of the twenty-nine left streaks. On the night of the 13th the shower was seen by the writer at Bristol, where observations were commenced in the early evening at $5^h\ 30^m$, and maintained until 17^h, during which period exactly 100 shooting stars were recorded. Of these, eighteen were *Leonids;* four of them were brighter than the stars, in fact the meteors generally from this shower are finer than the average. The radiant point was very distinctly shown at 148° + 23°, being extremely near Mr. Corder's position and to Professor Herschel's average centre at 149° + 23° for the great shower of Nov. 13, 1866. Every meteor left a bright streak, and the flights as registered are exhibited in the accompanying plane-perspective diagram (Fig. 2).

The maximum occurred at about 15^h, Nov. 13, when these bright *Leonids* were appearing in rapid succession; but immediately afterwards a lull ensued, and meteors came only one now and then from the sickle of *Leo,* now risen high and clear in the eastern sky. The position of the radiant as determined this year coincides exactly with previous observations, and is shown in the annexed sketch (Fig. 3):—

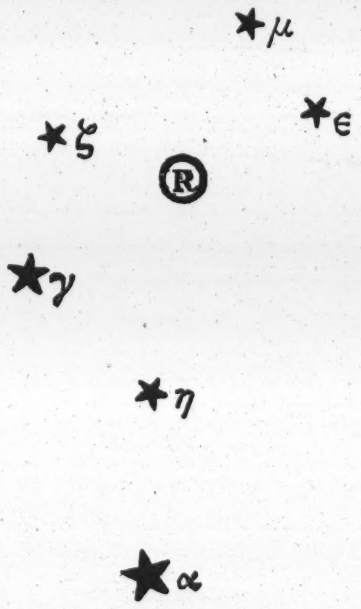

Fig. 3. Position of the radiant point (R) among the stars in the Sickle of *Leo.*

On the night of November 14, the shower was observed by Mr. Gray at Bedford, who, however, failed to see the outburst on the preceding night. He says: "Part of the sky was observed from $7^h\ 30^m$ to $8^h\ 30^m$, and from $9^h\ 30^m$ to 18^h. Thirty-eight meteors were seen; at 14^h and 17^h they followed

in somewhat quick succession—ten were notably bright, and one equalled *Venus* in size and brilliancy. Of those whose paths were recorded most radiated from *Leo;* of the remainder many were traceable from the region around *α* and *β Geminorum*, but I was unable to find the exact position of the radiant point."

On the following night, Mr. Sawyer, at Cambridgeport, Mass., observed seven *Leonids* in a watch of two hours, and found the radiant point at 151° + 22°. Other reports from America confirm the reappearance of the shower on the mornings of November 13 and 14.

I have been particular to mention the facts of the recent display of *Leonids*, because it goes far to prove that they form a continuous stream, like the *Perseids*, and that the shower is visible every year with more or less intensity. At the present time the parent comet is nearing its aphelion (close to the orbit of *Uranus*), a vast distance from the Earth, and none but the most widely separated of its particles could have encountered the Earth at her recent approach to the node. It is a significant fact that now (thirteen years after the maximum in 1866) the shower has recurred on several successive nights in the most decided manner.

The remarkable display from near *γ Andromedæ* due at about the end of November, and having no sort of connexion with the *Leonids* to which we have been referring, was first witnessed on December 7, 1798, by Brandes whilst travelling near Hamburg in Germany. Four hundred meteors appeared in half of the sky during a few hours. On the same date in 1830 many shooting-stars were seen by the Abbé Raillard in France. On December 6, 1838, a meteor-shower was observed by Paul Flaugergues at Toulon, and by Herrick in the United States. At the Brussels Observatory meteors were recorded to be four times as numerous as on an ordinary night. On December 8, 1847, Heis saw a meteoric shower with a radiant at 25° + 40°; and on November 30, 1867, Zezioli noted a few meteors from a centre derived by Schiaparelli at 17° + 48°. On November 27, 1872, a great shower of meteors was seen in many parts from a radiant point at 25° + 43°. They fell so thickly during several hours that it was almost impossible to record the approximate numbers. During the next few years the shower became quiescent, but in 1877, November 25, the shower recurred again, and was slightly seen by the writer. On the 27th it continued feebly in progress, but the exhibition was a very meagre one. In 1878 a conspicuous apparition was looked for, but astronomers were disappointed. The shower failing in 1878 it was confidently asserted that in 1879 the conditions being more favourable, we should again become immersed in the dense portion of the meteor flight;

but nothing was seen on the predicted nights, indeed signal failure everywhere attended the observers. At Bristol, on the 27th, the sky was clear at intervals, and a carefully directed watch was instituted at several periods of the night, but no meteors were traced in the bright moonlight. The sky was cloudy on the 26th and 28th, when possibly there may have occurred some revival of the shower, or it may have taken place in the day-time, but it is certain that nothing of it was seen in England. Reports from foreign observatories* may perhaps be more favourable, but in the moonlit sky at the end of November observers had a poor prospect of seeing many meteors, unless indeed a very conspicuous display occurred. Thus the shower of meteors appears, like its derivative comet, to have eluded the search of astronomers; and in the event of its non-recovery in future years it will be conjectured that the stream has been deflected away from the neighbourhood of the Earth's orbit under the influence of planetary perturbations.

Apart from the *Leonids* and *Andromedes* of November, there are many other systems presented during that month; of these the *Taurids* and a bordering shower in *Musca* supply the chief examples, and they have afforded an abundant supply of meteors during the past month. Mr. Corder says: 'Several clear nights in the first half of November allowed of good watches for the *Taurids*, but the number seen was not large considering the length of the observations. There are some slow meteor-radiants near to this main stream which may possibly be connected, but of the true *Taurids* fifty-three were seen, and a total of eighty-five when the branch radiants are included. Of this number six were first mags., and they were curious, for they left very narrow red streaks, which is not usual with slow trained meteors. They did not appear like the gaseous streaks of the *Leonids*, but were extremely faint as if only from red-hot ash. The colour of the largest ones was greenish yellow; many of the small ones were reddish. Radiant point at 58° + 21°, and others in *Musca*, the chief, at 47° + 23°.' These observations were fully corroborated at Bristol on the nights of November 12-14, when two very active showers were seen from the points 60° + 21° and 46° + 21°, and there were a large number of minor showers in play at the same epoch. Observers should watch for the annual returns of these numerous *Taurids* and for the other co-operative displays of the season. The *Leonids* and *Andromedes* must be diligently looked for every year, so that we may learn more of their history and store up the materials for future discussion and investigation.

* Mr. Sawyer writes from Cambridgeport, Mass., that he obtained frequent observations between Nov. 23–30 and Dec. 1–5, but there was no sign of the expected meteors.

THE LAW OF ASSOCIATION IN THE ANIMAL KINGDOM.*

By M. EDM. PERRIER.

ONE of the characteristics of the course of instruction at the Museum, has always been that it exercised a considerable influence upon the men who have to carry it out. Compelled by the very nature of the institution to keep himself constantly acquainted with what is known and what is sought, with the definitive acquisitions of science and the objects of her aspirations, obliged to co-ordinate the most recent discoveries with those which preceded them, to test all new theories and ideas, and to bind together the materials which incessantly accumulate about the stones forming the vast edifice of science, the professor sees the lines of that edifice become gradually modified, contributes personally to the accomplishment of their metamorphosis, and sometimes concludes his course under the domination of ideas quite different from those which inspired him at starting.

I admit without reservation that I have undergone this influence. Last year I commenced a series of investigations upon transformism. I had no prejudices with regard to this doctrine. If certain general ideas attracted me towards it, I had also present to my mind the objections repeatedly urged against it by the most illustrious of French naturalists, and among these the men for whom I have the greatest esteem and veneration. It seemed to me, however, in the course of my lectures that these objections were by no means insurmountable, that they were directed against modes of conception of the evolution of organisms which were not at all necessary, and that they left perfectly intact the actual bases of the doctrine. Ascending the series of organisms from the humblest to the

* This article, which contains a great deal of interesting information and some original and suggestive views on the relations of animal forms, is slightly abridged from M. Perrier's opening lecture at the Museum of Natural History of Paris.

most perfect, and seeking among them not differences but relationships, it seemed to me that a simple and very general law had presided over their formation; that they were derived one from the other by a constant process; and I found that I had added some additional arguments to the theory of the genealogical relationship of species.

The law which I now have to put forward may be designated the *law of association*. The process by which it has produced the greater number of organisms is the *transformation of societies into individuals*.

From the day when it was proved that every living creature was composed of microscopic corpuscles more or less resembling each other, from the day when it was seen that similar corpuscles capable of leading an independent existence constituted of themselves the simplest organisms, it has been thought that we might compare the highest animals and plants to vast associations of distinct individuals, each represented by one of these living corpuscles, one of these *cells*, to use the term adopted by anatomists. In the same animal the cells may display a great number of forms and different physiological properties. These forms and properties are not in the least degree modified by the vicinity of different cells. In the very heart of an organism each cell lives as if it were alone—that is to say, if it were possible to isolate a cell from the human body and to place it in a nutritive medium like that which normally surrounds it, that cell would continue to live, to obtain nourishment, to develope and reproduce itself: in a word, it would exercise all its physiological functions precisely as before. But more than this; in the organism itself the life of each cell is so independent of that of its neighbours that it is possible to kill all the cells of the same kind without affecting the others. Claude Bernard has demonstrated that curare poisons the elements which terminate the motor nerves, thus abolishing all movement, without in the least injuring the other parts of the nervous system, and, in particular, leaving sensibility absolutely intact. It was in consequence of his investigations upon curare that he asserted, more distinctly than had ever been done before, the principle of the *independence of the anatomical elements*.

Thus, in organisms, not only are the elementary individuals sometimes very dissimilar, but in spite of the bonds which unite them, they retain all their personality. We may therefore compare an animal or a plant to a populous city in which flourish numerous corporations, the members of which, each on his own account, practise some particular art or industry, and yet contribute to the general prosperity through the activity of the exchanges which occur throughout; in the higher organisms a

peculiar corporation, incessantly in action, is the ordinary medium of these exchanges; the blood globules are true traders, conveying with them in the liquid in which they float, the multifarious merchandize in which they deal.

All the comparisons that could be furnished by the degrees of relationship were employed to express the affinities presented by animals even before it was supposed that any real consanguinity existed between them; and just in the same way the organisms themselves have always been compared to societies, or societies to organisms, without any recognition that these comparisons were otherwise than purely ideal. On the other hand, we arrived last year at the conclusion that association had played an important if not an exclusive part in the gradual development of organisms; we find absolutely convincing proofs of this in the history of Polypes, and of the Vermes; the affinities of the latter to the Arthropods are doubted by no one; and we have shown how these same Vermes are connected with the Mollusca and the Vertebrata. The theory therefore extends to the whole animal kingdom.

But, in the first place, what are we to understand by association? In saying that animal organisms have been chiefly produced by the transformation of animal societies into individuals, what are we to understand by the term *societies?* Are we to say that every society of living creatures may be an individual in course of formation? Certainly not; but there are animal societies, in which the relations of the individuals are so close that each individual is not only in immediate contact, but also in histological continuity with its neighbours. To such a society we give the name of colony, which some naturalists have changed to *cormus*. The individuals composing these colonies, or *cormi*, are not always indissolubly united to each other. They may separate from their companions, live isolated for a longer or shorter time, and even form new colonies, thus indisputably asserting their independence. In the same zoological group we may find allied species, in some of which the individuals live always solitary, while in the others they are on the contrary always associated. This is the case in the very remarkable group of the Polypes or Acalephs.

One species of this group—the brown Hydra (*Hydra fusca*)—is common in our stagnant waters, and even in very small garden basins. It has never ceased to excite the interest of naturalists and philosophers since Trembley first made known its marvellous faculties. These Hydras usually live solitary, but frequently the larger individuals may be seen bearing smaller ones upon the wall of their body. In a Hydra kept in confinement the development of these may be followed step by step. They are

at first simple swellings, into the middle of which penetrates a prolongation of the body-cavity of the parent; this swelling enlarges, and speedily puts forth some tentacles; a mouth then opens in the middle of the circlet formed by the latter. The young Hydra, like its parent, is a simple sac, the wall of which is composed of a double series of cells, and of which the cavity, playing the part of stomach, communicates directly with the stomach of the parent, so that the contractions of the body may transmit any food captured by the one into the stomach of the other, and *vice versâ*. The parent and child live for a longer or shorter time in this close union; but when the young animal has attained a certain size, it detaches itself, adheres to some neighbouring leaf, and begins to hunt for prey on its own account. Very soon the parent and the young Hydra cannot be distinguished from each other, and both of them continually produce new Hydras throughout the summer.

In water abounding in food, and often in captivity, however, things go on rather differently. Each Hydra retains its progeny; the young ones increase in size, and produce new Hydras without separating from their parent. A true society is founded. Trembley for a long time kept a Hydra, which bore as many as twenty-two young ones of different generations. It was a living genealogical tree.

What is only occasionally produced in the common Hydra, becomes absolutely normal in another fresh-water species, *Cordylophora lacustris*, and in most of the marine Hydroids, in which the colonies are often composed of innumerable individuals. But then a new phenomenon occurs—the social life becomes complicated; an actual *division of labour* is effected between the members of the same colony. At first all were similar, all performed the same functions in the same manner; but speedily each individual becomes specialized. One devotes itself exclusively to the capture of food; another to the elaboration of the nutritive material; and a third to reproduction; so that in the end all these individuals, which originally had no need of one another, become mutually necessary; and by this means the society acquires a greater coherence, all its members being henceforward bound together as partners. Among the Hydractiniæ we may reckon no fewer than seven kinds of individuals, namely,—

1. The nutritive individuals, or Gastrozooids;
2. The prehensile individuals, or Dactylozooids, furnished with bunches of urticating capsules;
3. Dactylozooids without urticating organs;
4. Defensive individuals;
5. Reproductive individuals, destined to produce the sexual individuals;

6. Male individuals;
7. Female individuals.

These individuals are not distinguished only by the functions they fulfil; they are also distinguished by their external form, so that a peculiar kind of individual corresponds to each special function. Each of them, so to speak, acquires the form of its employment, at the same time rising, or becoming retrograde in the scale of organization, so that here, as in human societies, the *division of labour* superinduces differences of condition. The species thus become polymorphic.

Of the seven kinds of individuals composing a colony of Hydractiniæ, the nutritive individuals alone seem capable of being self-sufficient. The others are destitute of mouth and of tentacles; the sexual individuals are reduced to simple sacs; the defensive individuals seem to be only horny spines, between which the polypes can retract themselves. In presence of these facts, it would seem to be an exaggeration to attribute the quality of individuals to these different parts; we have here, it might be said, simple organs. But organs of what? They are just as independent of each other, just as independent of the nutritive individuals as the latter can be of one another. Hence they are not organs of those polypes. Are we to see in them organs of the colony? This is at once to recognize that the colony has an individual character, and consequently to assume the transformation that we seek to demonstrate. But how has a colony been able to acquire such organs? whence can they have arisen if not from a transformation of the individuals composing it?

However, we have no occasion for hypothesis in order to demonstrate that these *colonial organs* are the equivalents of true individuals. The buds which give origin to the different kinds of individuals in a colony of Hydractiniæ all originate in the same way, and they are for a long time so similar that there is nothing to enable one to distinguish them. This furnishes a first presumption in favour of their equivalence; but in the allied type *Podocoryne* we see the humble sac which represents the sexual individual replaced by a most active and elegant creature, much higher in organization than the Hydra itself, namely, by a Medusa, which detaches itself on its arrival at maturity, and swims about actively in the water, all the transparency of which it possesses.

These Medusæ constitute the most general form of the sexual individuals in the group of Hydroid Polypes, but they are themselves very multiform. From species to species their form is modified; we see them stop at every degree of development, sometimes becoming reduced to the condition of a mere bud, sometimes, although completely formed, abstaining from

casting themselves free, and terminating their existence in the colony from which they were born.

In one whole group of Polypes these Medusæ, or their equivalents, associate themselves with the reproductive individuals to form a new unit, a sort of small distinct colony, which may also be taken for a peculiar organ, the composition of which presents the most curious analogies with that of a flower. This reproductive apparatus has its separate chamber, the *gonangium*.

A step further, and we shall see these Medusæ, the individuality of which is, if possible, still more strongly marked than that of the Polypes, themselves descend to the rank of organs in more complex colonies.

All the colonies of Hydroids do not live attached to submarine objects. There are some which lead a vagabond existence. They have often, and not without reason, been taken for simple animals analogous to the Medusæ, and designated by the name of Siphonophora, which has remained attached to them. They sometimes attain a large size, and the variety and number, I may say the profusion of the parts of which they are composed, together with the brilliancy of their colours and the incomparable beauty of their forms, have always been a source of profound admiration both for the naturalist and the sailor. Now each of these parts is the equivalent of a Hydra or of a Medusa.

In an *Agalma*, as in the Hydractiniæ, we find nutritive individuals furnished with a long tentacle, the mere contact of which produces an intense burning pain,—a kind of *fishing-line*, capable, in the larger species of Siphonophora, of capturing even fishes. Side by side with these nutritive individuals, we find others destitute of mouths, which are nothing but the reproductive individuals, in the vicinity of which are the sexual individuals, in form very like the Medusæ. All these individuals are fixed upon a common axis, floating and undulating in the water, sustained by a sort of aeriferous bell, which forms its superior extremity; two series of sterile Medusæ beneath this bell simulate a set of rowers, to which the entire colony abandons the duty of moving it about.

In every respect these various parts are so like the Hydræ and Medusæ, that we cannot for a moment refuse to accord to them the character of individuals; the *Agalma* and the other Siphonophora are, therefore, true societies or colonies. But then most of the individuals cannot, without risk of death, be separated from their companions; and, indeed, in certain cases, all co-ordinate their movements to enable the colony to accomplish certain actions. For example, the Portuguese men-of-war (*Physaliæ*) are often seen to change their course, and

then all the individuals of the colony assist in the operation. There is consequently a will that governs them, a will which can only draw the motives of its determination from the existence of a sort of social consciousness, raising the whole colony to the rank of a psychological unit. Composed of individuals each equivalent to one of those Hydræ or Medusæ which we have seen living freely and sufficient for themselves, every Siphonophore must nevertheless be regarded in its turn as a single animal, as a true individual of a higher order. Here the transformation of the colony into an individual is to a certain extent manifest. The Siphonophore is an animal, all the organs of which are so many distinct animals, each playing a certain part. Moreover, we see these animal-organs gradually become less and less independent. They approach others, arrange themselves regularly around a central individual, which predominates, and finally combine to form a creature, such as the *Porpita* or the *Velella*, in which no one would dream of seeing anything but an indivisible animal if the investigation of the allied types did not reveal its true nature.

It is thus, also, that every one hitherto has regarded the Sea-anemones and the Polypes of the madrepores and coral, as simple organisms, primary individuals, although, in our opinion, they owe their origin to a phenomenon exactly like that which has produced the *Porpitæ* and the *Velellæ*, and likewise result from the union of three kinds of Hydriform Polypes. The fine investigations of Moseley on the Polypes of the family Stylasteridæ furnish an unexpected proof of this. Considering only their calcareous parts, all these creatures seem to be true Madrepores, and the first doubt as to their actual nature was raised by Louis Agassiz with reference to the Millepores.

Between a Coralliarian and a Hydroid Polype the difference is considerable; one is a simple sac, bearing tentacles which vary in number with the species, sometimes with the individuals, but constant for each of them during the greater part of their existence; these are usually solid, simple appendages of the wall of the body. The other consists of a stomachal sac, open at the bottom, and around it are arranged hollow tentacles, the number of which increases with the age of the polype. These tentacles, which have their upper parts free and are united by their bases, thus forming the body-wall of the polype, open inwards, like the stomachal sac, into a great cavity, the periphery of which is divided into as many chambers as there are tentacles by the united walls of each two neighbouring tentacles. Upon the partitions of these chambers the reproductive apparatus is developed, and it thus seems to be contained within the body cavity of the polype, whilst in general it appears in the Hydroid Polypes in the form of an external bud.

The Coralliarian Polype is therefore constructed upon a very complicated type in comparison with the Hydroid Polype, and it is the latter type that we find realized very clearly in the Stylasteridæ. Their colonies present the polymorphism peculiar to the Hydroids. In them we constantly find nutritive individuals, or gastrozooids, purveying individuals, or dactylozooids, and reproductive individuals, or gonozooids. In *Spinipora*, *Sporadopora*, *Pliobothrius*, and *Errina*, these different kinds of individuals are perfectly independent of each other; a simple vascular network distributes among them the nourishment seized by the dactylozooids and elaborated by the nutritive individuals or gastrozooids.

But in the Millepores the gastrozooid decidedly acquires the predominance. An important member of the colony, since it is this which prepares the nourishment for all, it attracts around it the dactylozooids and reproductive individuals; all range themselves in a circle round the principal individual, but without entering into any intimate union with it.

In *Astylus*, *Stylaster*, and *Cryptohelia*, this movement of concentration round the gastrozooid becomes still more strongly marked; a vacant place is formed beneath it; its tentacles, rendered useless by the vicinity of the dactylozooids, finally disappear; it is reduced to a simple digestive sac, around which the dactylozooids perform functions exactly like those of the tentacles of a Coralliarian Polype. Here again, each system has very decidedly its own individuality, but with another step, the dactylozooids, still distinct throughout their length, become united at the base and attach themselves to the gastrozooid, and the gonozooids follow them in this movement. These different parts are thenceforward too close together to need a special vascular system to place them in communication; the vessels which united them are no longer more than simple perforations of their wall, all opening into the vacant space situated beneath the gastrozooid, into which the gonozooids themselves also penetrate; but this whole, the most experienced naturalist would thenceforward be unable to distinguish from what we call a Coralliarian Polype.

The individual in the Coralliarian Polype is consequently an association of parts differing in form, each of which is equivalent to a Hydroid Polype.

A Coralliarian Polype furnished with twelve tentacles, is the sum of a considerable number of Hydroid polypes, namely, a gastrozooid, twelve dactylozooids, and an indeterminate number of gonozooids. It is formed by means of the Hydroid polypes, like the flower by the agency of the leaves of the plant which bears it, or better still, like the composite flower by means of its florets. The phenomenon which has produced this polype

is the same that has produced the *Porpita*, or the *Velella*,—the *formation of the colony*, or *association*, the *physiological division of labour*, the *manifestation of polymorphism*, and finally, the *concentration of the parts thus elaborated*. Such, from the morphological point of view, is the succession of the phenomena which mark the transformation of the Hydroid Polypes into *Velellæ* and Sea-anemones. The Hydroid Polypes are the raw materials which are brought into the factory, and then fashioned and definitely assembled to form these superior individualities.

Whilst these phenomena are occurring in the morphological sense, others are manifested in the physiological. The associated individuals have at first nothing in common, unless it be the nutrition, which all are capable of elaborating, but which passes from one to the other in such a manner that all the members of a colony may equally partake of it; this is in reality the commencement of solidarity, but each polype, nevertheless, possesses its own personality. It has its personal will, and does not communicate to its neighbours the sensations it experiences; we may wound, or even remove it altogether, without any consciousness on the part of its neighbours. But in proportion as the colony becomes more coherent, the sensations radiate further and further around the polype; very soon all the individuals are sensible of actions performed upon any one of them; a *colonial consciousness* is thus manifested over and above the individual consciousness; and, finally, a single will bends all the special wills to its bidding. At this moment a new individual is definitively constituted.

The transformations that we have been able to trace, step by step, in the class of Polypes, are not peculiar to those animals. It would be just as easy to show how simple forms have in the same way become associated in the great group of the Vermes, to lead up to complicated forms; it would be just as easy to recognize in this interesting group the laws to which the study of the Polypes has led us. It is already a long time since Professor Van Beneden asserted that each joint of a Tapeworm was the equivalent of a Trematode worm, a Fluke; and for a still longer period the segments of a worm, or of an insect, have been regarded by naturalists as perfectly equivalent units, all formed of the same parts, and each having an actual individuality. The name of *zoonites*, which has been applied to them, would even seem to indicate a tendency to regard them as actual *elementary animals*, which had formed colonies by their association. The faculty possessed, in certain worms, by each of these segments of individualizing itself, and forming a new colony, bears high testimony to the correctness of this view; polymorphism and the concentration of parts suffice to explain how a *Peripatus* or a Myriopod may have become trans-

formed into an Arachnid or an Insect, how the various Crustacea have issued from a common stem, and how, from another form of colony, the Annelidan series may have proceeded.

On the other hand, it has been repeatedly maintained that the Sea-urchins, the Starfishes, and the Ophiurans, were nothing but colonies of worms soldered together by the head; they are certainly colonies, but of a very peculiar nature.

Can we say the same of the Mollusca and Vertebrata, all the parts of which seem to us to be so intimately fused together, and which are the giants of creation? Are there simple forms the association of which could explain to us the marvellous organization of these superior types, as we have explained the formation of the Siphonophora, the Coralliaria, the Echinodermata, the Vermes, and the Arthropoda? This is what we have still to investigate, but it is important to remark, that whatever may be the result arrived at, the generality of the principle of *association* will not be at all invalidated. If, in opposition to the presentiments derived from our previous studies, these simple individualities never existed, we should have in fact to compare the Mollusca and the Vertebrata with the primordial individuals, the combinations of which have produced the other types, and which we may still recognize as the base of all the great groups of the animal kingdom. Now, how did these individuals themselves originate?

The Hydræ and other analogous organisms furnish our answer. We may cut a Hydra into as many pieces as we like, each of these pieces, far from dying, continues to develope itself, and, finally, reconstructs the perfect Hydra. What are we to conclude from this, if not that the different parts are independent of each other, as the polypes forming one of the lowest colonies are of their neighbours? Each cell of the Hydra is an actual individual, and the Hydra is a colony of these unicellular organisms, just as the Siphonophora are themselves colonies of Hydras. The aptitude for social life is communicated by heredity to these cells as to the polypes. Each cell, and each polype, when detached from a colony, bears within it, as it were, the *effigies* of the colony, and its subsequent development tends always to the reconstruction of the latter. At first, all the members of a colony are equally apt to reproduce it; thus this faculty, like the others, becomes localized and tends to become the appanage of certain individuals or of certain parts; at the same time sexual reproduction gradually increases in importance; and when the society has attained a certain degree of coherence its different parts cease to be able to live independently of each other. As in the case of old people who cannot be separated after a long existence

together without exposing them to death, the different parts of a highly individualized society die without being able to reconstruct themselves; the reproductive function is thus exclusively reduced to its sexual form.

The Sponges reveal to us their colonial nature even more distinctly than the Hydraids. In them, in fact, the *Spongiarian individual* is certainly constituted by two kinds of *cellular individuals*, the Amœba and the flagellate Infusory, the analogues of which are to be met with at liberty in the state of isolated individuals. The flagelliferous cells of Sponges present quite exceptional peculiarities; they are furnished with a nucleus, and a contractile vesicle, and their flagellum is surrounded by a membranous collar in the form of a funnel. All these characters are to be met with in the *Codosigæ*,* which are unicellular Infusoria that always live isolated, and which in consequence are to the Sponges what the Hydras are to the Siphonophora and Coralliaria. In the *Anthophysæ* these cells always live in colonies, but they are still all alike. Let polymorphism step in,—let some of the associated cells retain the flagelliferous form, whilst others become Amœbæ (a transformation which is quite possible, since it is one of the most frequent modes of reproduction of the amœboid Infusoria), and the *Anthophysa* is transformed into a sponge. Thus the process is always the same; whatever may be the materials which Nature brings together, cells or polypes, she subjects them all to the same elaboration in order to obtain from them new individuals.

The cells, when once brought together, may moreover, within the organisms containing them, undergo in a high degree those metamorphoses which are the consequence of the physiological division of labour, and form diverse organs, although these organs cannot be regarded as actual individuals. If the individuals of a colony often descend to the state of organs, we must not conclude from this that the organs of an animal are always individuals which have lost their autonomy; but the animal to which they belong, although it may never have been an assemblage of individualities intermediate between its own and that of the cells, is none the less a colony of the latter, subjected to the laws of evolution of all the others.

Thus, even if it should be proved that the Vertebrata and the Mollusca are not the result of the fusion of simpler organisms which have once been able to lead an independent life, they would be none the less colonies of cells, and the *law of association* would lose none of its generality.

It remains the fundamental law of the development of the

* See an article by Mr. W. Savile Kent, in *Popular Science Review*, N. S., Vol. II., p. 113, with illustrations.

animal kingdom, including and governing those *laws of growth*, of *organic repetition*, and of *economy*, which have long since impressed the minds of physiologists, explaining the *homologies*, hitherto so mysterious, which are observed between the different parts of the body and the different kinds of limbs of the same animal, and bringing into a single group all the forms of sexual generation, which are its most powerful means of creation. Supported upon the law of the *physiological division of labour*, the importance of which was first demonstrated by M. Milne-Edwards, and upon that of *polymorphism*, which, without it have no precise meaning, and can only have a very restricted bearing, and in its turn the consequence of the *law of division* of protoplasmic masses, it has been the great producer of organisms, and establishes, in an unexpected manner, a fresh bond between sociology and those branches of biology which relate to the constitution and functions of organisms.

We now come to the ultimate elements of living bodies, the materials which have served for the construction of the simplest of them, and we may ask ourselves what may have been their origin. Here we are in the presence of unity; there is no longer any question of association. Most living cells consist of four parts; an enveloping membrane and semi-fluid contents, in the midst of which we observe a peculiar globule, the nucleus, itself containing a nucleolus. Of these four parts, only one is truly indispensable, namely, the semi-fluid contents, which are either perfectly limpid, or finely granular, the *protoplasm*. It is in this curious substance that resides life, which has no need of any other apparatus to manifest its essential characters. Some particularly remarkable creatures, the Monera, are exclusively formed of it. These are simple, perfectly homogeneous clots of a limpid jelly, like white of egg. This jelly, nevertheless, performs movements, captures animals, digests them, incorporates them with its substance, enlarges, and divides, when it has attained a certain size, into two or more small masses, which recommence the life of their parent, and like it divide when they have reached a certain size.

This faculty of division is an important property of protoplasm, for it governs all organic evolution. A protoplasmic mass cannot exceed a determinate size. When it attains this size it divides, and as its mass is perfectly homogeneous, as it is constantly acted upon by currents which mingle the different parts of its substance, the fragments produced by this division possess all the acquired or inherited properties of the protoplasmic clot of which they formed parts. This is the whole explanation of the important phenomenon of *heredity*, by virtue of which every organism transmits to its progeny (even in the

case of sexual generation) all its specific, and even a part of its personal characters.

From this incapacity of the protoplasmic masses to exceed a certain size, it follows, necessarily, that all the creatures which exceed this size, must be formed of several distinct masses of protoplasm, and, in one word, will be colonies. Thus the generality of the law of association is shown to be a consequence of one of the fundamental properties of protoplasm.

The latter constantly breaking up into distinct masses, these masses, which there is nothing to bind together more directly, are each modified in a particular way under the influence of external agents, and thus has been introduced into nature that marvellous variety which strikes us with admiration; it is an immediate consequence, like the law of association, of the obligation imposed upon protoplasm to divide into small distinct individualities.

Now what is the nature of protoplasm? Struck with its homogeneity, and with the identity of the elements composing it with those which form albumenoid substances, it has been thought that it was a mere chemical compound, and it has even been a question whether it might not be possible to produce it artificially—whether man might not be able to rekindle the torch of Prometheus and create life at his own pleasure—a serious question, which, I believe, has only been put in consequence of a strange confusion of words. If it be true that the substances which form living matter are the same as those which enter into certain chemical compounds, we cannot conclude from this that protoplasm is one of these compounds. The characteristic of a chemical compound is fixity of composition; the composition of protoplasm, on the contrary, changes incessantly, without any of its fundamental properties being modified. New substances are constantly entering into its mass, while others issue from it; protoplasm is in a state of perpetual decomposition and recomposition; it is not its chemical composition that characterizes it, but the mode in which it is incessantly decomposing and recomposing itself; everything in it is in movement, and, properly speaking, it is this movement that characterizes life.

Life is therefore nothing but a combination of motions, or, if it be preferred, a mode of motion of which certain substances alone are capable, and which is not without some analogies with those whirling motions to which certain eminent physicists ascribe the formation and the properties of the atoms of chemistry. We might follow out this comparison between the atoms and protoplasms, and employ it to show that the latter must have been formed originally in the greatest possible number, that it

would appear that we must always be incapable of reproducing them, that they appeared with a whole host of properties which have governed all their subsequent destiny, and that they showed themselves from the first with the individuality that we see in them at the present day.

THE DINOSAURIA.*

By Professor H. G. SEELEY, F.R.S., F.G.S.

[Plate II.]

EXACTLY fifty years ago Hermann von Meyer, the greatest comparative anatomist that Germany has produced, recognized the fact that the extinct reptiles of the secondary strata have characters in common, which separate them from their living allies; and he proposed to name the group Palæosauria. He further defined this sub-class of the Reptilia as comprising three chief divisions; first, flying animals, now termed Ornithosauria or Pterodactyles; secondly, swimming animals, such as Ichthyosaurs and Plesiosaurs, which he named Nexipods; and thirdly, animals resembling the larger and heavier land mammals, which he called Pachypods. These divisions were at once generally accepted, though the name Pachypoda has given place to Dinosauria. It is impossible to over-estimate the philosophical merit of Von Meyer in dealing with these fossil remains, especially when their fragmentary nature is remembered; and also bearing in mind the slow growth of knowledge which has enabled us to confirm and appreciate the truth of his views concerning the Dinosauria.

Von Meyer's opportunities were almost limited to the study of fossils found in the Triassic rocks of Central Europe; and owing perhaps to the slow diffusion of scientific information, the somewhat similar remains which were met with in the Wealden strata of the south-east of England were studied without regard either to the evidence furnished by German specimens, or to Von Meyer's generalization.

* This lecture was originally delivered on the 19th April, 1879, at the Scientific Club in Vienna. An abstract of it, rendered in German by Count Marschall, has already been issued in the *Monatsblätter des wissenschaftlichen Club in Wien.*

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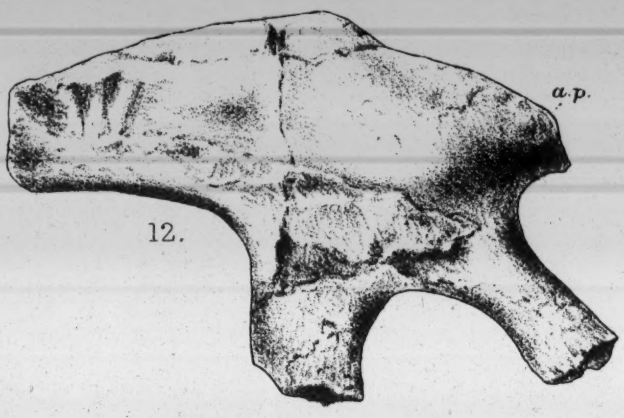

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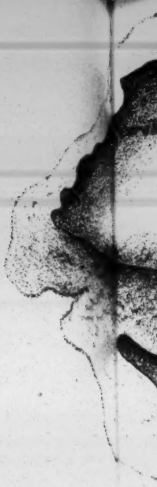

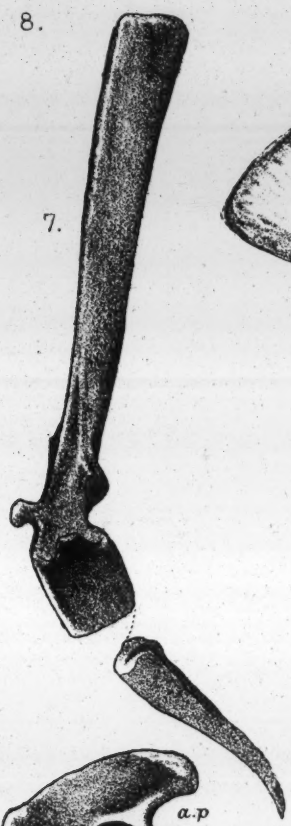

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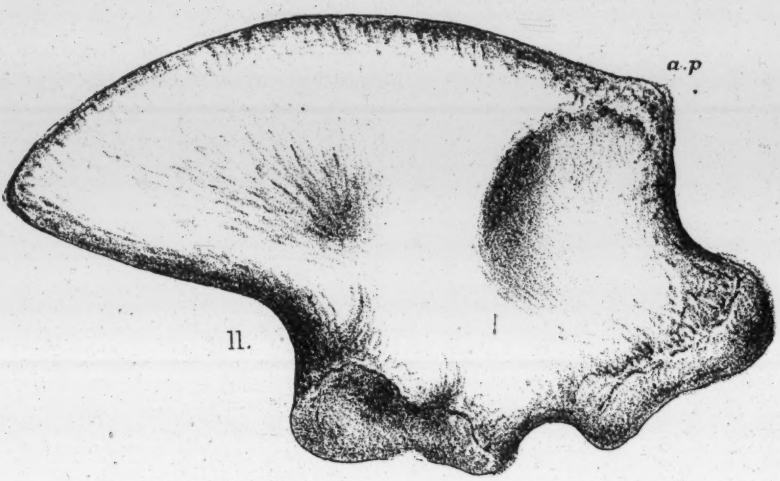

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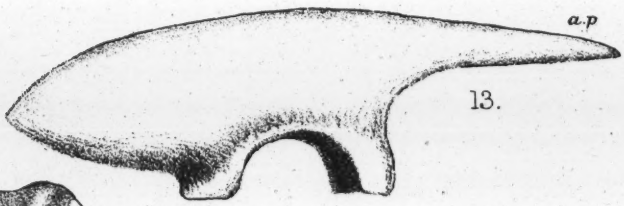

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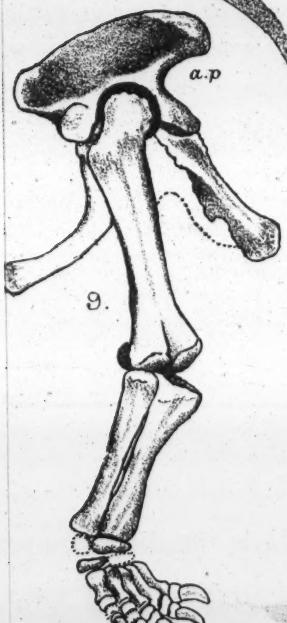

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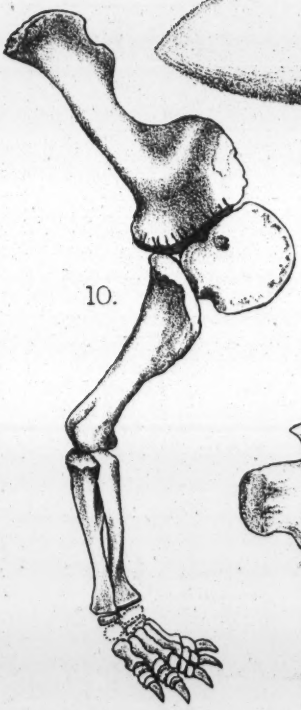

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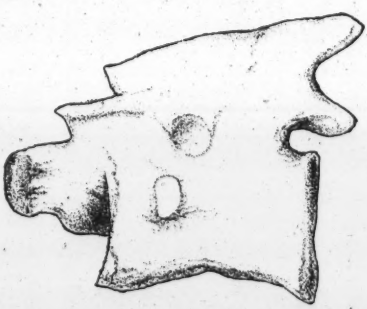

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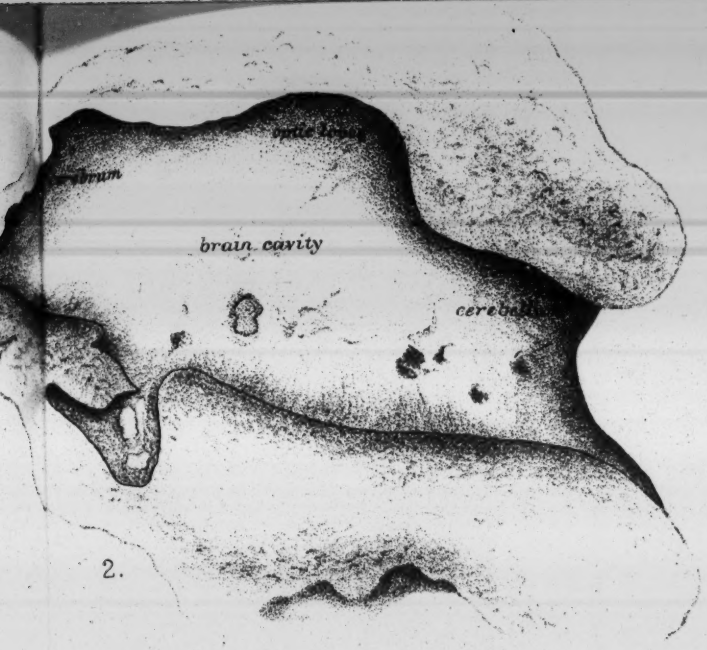

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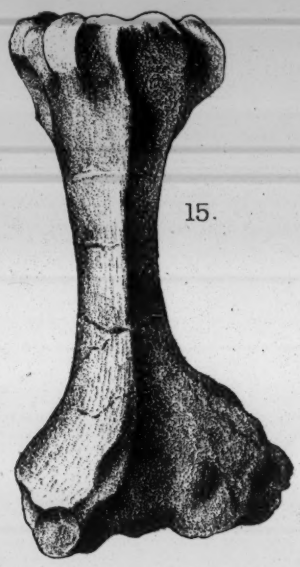

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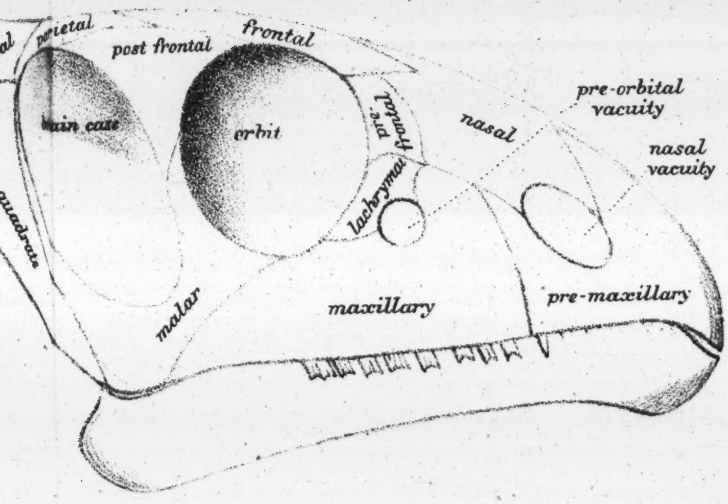

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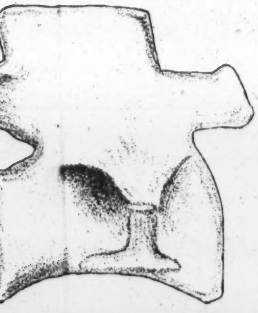

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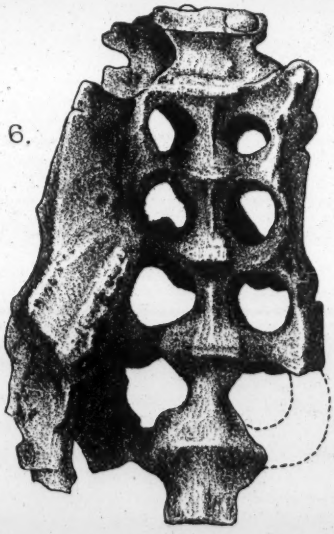

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INOSAURIANS.

The great merit of Mantell's discoveries is not easily undervalued, when the large collections which he formed are studied in the British Museum; and the many memoirs in which he made their structures known enunciate conclusions which Professor Owen in most cases adopted when afterwards describing the Fossil Reptilia of Britain.

Mantell, however, affiliated the animals which he found to the Saurians, for in those days the order Sauria was often used to comprise both Lizards and Crocodiles, so that a blending of the characters of bones from both these groups of animals appeared in no way unnatural. But, probably, Cuvier's suggestion concerning the resemblance of the teeth of Iguanodon to the teeth of the living Iguana, and the knowledge that teeth among the higher group of mammals often furnish unfailing evidence of the skeletal characters of the animals to which they belong, especially influenced Mantell in regarding these fossil Saurians as little more than gigantic fossil Lizards. The wealth of materials furnished by the English strata for a long time drew to their study some of our ablest anatomists; but it was not till 1859 that Professor Owen proposed to separate them from Lizards, and instituted the order Dinosauria, which was chiefly defined by having more than two vertebræ in the sacrum. The Dinosauria are nothing more than Von Meyer's Pachypoda under a new name. Professor Owen, however, was hindered from fully appreciating the true nature and structure of these extinct animals by a few identifications of parts of the skeleton which have since been better elucidated. Thus, the animals were at first supposed to have long clavicles somewhat like those of Lizards, and the coracoid was also supposed to be in the main like that of a Lizard. The bones of the hind limb and pelvis were imperfectly known or understood; and it was not until Professor Cope, aided by beautiful specimens from the Greensand of New Jersey, studied the anatomy of Dinosaurs, that it began to be understood that many of the Dinosaurs had a kangaroo-like form, and that bones which were referred to the arch for the support of the fore-limb really belonged to the arch for the support of the hind-limb. Shortly afterwards Professor Huxley, in 1868, independently came to conclusions almost identical with those of Professor Cope; and, aided by the material discovered by Professor Phillips in the Forest-Marble near Oxford, was able to demonstrate that the supposed coracoid was the ilium, and the supposed clavicle was the ischium. There exists fortunately in the Oxford Museum a cast of the tibia and astragalus of Pœciloplеuron; and the character shown by these remains demonstrates that in this part of the skeleton Dinosaurs present the closest possible resemblance

to birds. Since the pelvis was bird-like, and the tibia and tarsus bird-like, and the early dorsal vertebræ were often convex in front and concave behind, like the later dorsal vertebræ of Penguins, Professor Huxley strongly supported Cope's conclusion that the Dinosauria made a near approach to birds. In later years Mr. Hulke, in England, has added largely to our knowledge of the Dinosaurian skeleton; while in America, Professors Marsh and Cope have disinterred and described gigantic Dinosaurs, which for beauty of preservation and completeness of the skeleton surpass all the remains previously found in Europe. These later writers have adopted the doctrine of avian affinities for the Dinosauria.

The whole of the Dinosauria, so far as is known at present, were land animals, and their remains are most abundant in those formations which give evidence of near proximity to land, such as the Trias, Wealden, and Greensand formations; though they are represented in almost all the other Secondary deposits. From indications of the characters of hind limb, vertebræ, and skull, I am inclined to believe that Proterosaurus, found in the Permian, and best known as the fossil Monitor of Thuringia, must be included in the Dinosaurian order. In the Trias, especially of Württemberg, as may be seen in the magnificent collection administered by Dr. Fraas at Stuttgart, and in the University Museum established by Professor Quenstedt at Tübingen, Dinosaurs are especially abundant. Perhaps the most interesting types are Zanclodon and its allies, some of which are still undescribed. In England the Bristol conglomerate and other Triassic beds have yielded the remains of Thecodontosaurus, Palæosaurus, and Teratosaurus. The Lias at Lyme Regis has yielded Scelidosaurus, and at least one other undescribed genus; while another genus appears to be indicated in the Lias of Elgin. Megalosaurus, though especially characteristic of the Stonesfield Slate and Wealden beds, commenced, so far as can be judged from teeth, in the Lias, and continued, as Professor Suess has discovered, to the Upper Greensand. Ceteosaurus, if indeed that name can be retained, abounds in the Forest-Marble, Kimmeridge Clay, and Wealden beds. Cryptosaurus and Megalosaurus are both found in the Oxford Clay; Priodontognathus probably belongs to the Calcareous grit, though it may be Wealden. The Dinosaurs of the Kimmeridge Clay include Omosaurus, Gigantosaurus, and some doubtful forms; the Wealden beds are characterized by Iguanodon, which, however, ranges from the Kimmeridge Clay perhaps to the Upper Greensand. With it occur Hylæosaurus, Hypsilophodon, Pelorosaurus, Polacanthus, Vectisaurus, and Ornithopsis; while in the Upper Greensand of Cambridge, among other genera

are Macrurosaurus, Anoplosaurus, Syngonosaurus, Eucercosaurus, and Acanthopholis. The last genus also ranges into the Chalk. On the Continent, after the Trias, Dinosaurs are rarely found. Thaumatosaurus from the Inferior Oolite is a species of Pliosaurus, and has no Dinosaurian characters. The Continental Wealden specimens are as yet undescribed; but Professor Suess has found in the Gosau beds a rich Dinosaurian fauna, the general nature of which was briefly indicated by Dr. Bunzel. Professor Fritsch has figured a fragment of a Dinosaurian limb-bone from the Chalk of Bohemia, and long ago Dinosaurian bones were figured from the Maestricht beds, some of them closely conforming to the Iguanodont type. Nothing need be said now of the many American Dinosaurs described by Leidy, such as Cœlosaurus, Hadrosaurus, and Astrodon, which, together with Lælaps of Cope, occur in the Greensand of New Jersey; while in the Far West Professor Cope has found Agathaumus, Cionodon, and Polyonax. More recently there have been obtained from Colorado Camarasaurus of Cope, which appears to be identical with Atlantosaurus of Marsh, and is associated with genera named by the latter author Morosaurus, Apatosaurus, Allosaurus, and Diplodocus, and genera named by Cope Amphicœlias and Epanterias. It is, however, at present uncertain whether the latter genera are all distinct from the former.

This great succession of animals exhibits a diversity of organization, exceeding, so far as can be judged from the bones, that observed in any existing order of reptiles. It is probable that in the long period of geological time the group underwent evolution, not merely in the sense of the skeleton becoming modified by being adapted to altered conditions of existence, forced upon the animals by changing forms of the land-surfaces of the world, but also in actual progress from a lower to a higher type. Yet, with all this diversity, there is rarely any difficulty in recognizing the distinctive Dinosaurian characteristics of the animals, as shown in the transverse platform of the neural arch from which the neural spine rises, in the form of the scapular arch, and the pelvic girdle, and the characteristic shapes of the principal bones of the fore and hind limbs. But when the Dinosaurs first appeared in the Trias, the difficulty of defining the limits of the order is great on account of the way in which many of the types approximate to Crocodiles and other lower animals. In fact, the Triassic Crocodilia seem to foreshadow the Dinosaurs, though the two groups are contemporaneous. This is evident from the circumstance that Professor Owen formed the order Thecodontia to receive such types as the Thecodontosaurus, which Professor Huxley has shown to possess the essential charac-

teristics of Dinosaurian structure; and that Professor Huxley has himself thought it necessary to institute under the name Parasuchia, a division of the Crocodilia further removed from living crocodiles than the Teleosauria of the secondary rocks, for such extinct genera as Belodon and Staganolepis, formerly classed as Thecodonts. Von Meyer at first referred Belodon to the Pachypoda, but afterwards thought that Belodon was more of a Crocodile than a Lizard, and could not be included in that group. Many of the remains at first referred to Belodon from the Stuttgart neighbourhood are really referable to Zanclodon; but the true Belodon presents characters which show a singular transition in some respects from the Crocodile towards the Dinosaur. Thus with a Crocodilian twist the long femur has more the shape of a Dinosaurian femur than that of the Crocodile, and it has the characteristic Dinosaurian trochanter fairly developed on the inner side of the shaft, though placed a little higher than usual. The humerus is, however, much more Crocodilian in having the radial crest reflected downward instead of inward; and the animal was covered with immense and close set plates of dermal armour, which rested upon the expanded tops of the neural spines, and this covering gave to it a very Crocodilian aspect. Similarly, the Aëtosaurus of Fraas, sheathed in armour of a like kind, yet has a remarkably Dinosaurian type of pelvis; and the femur, like that of Belodon, shows the trochanter on the middle of the shaft, which is generally regarded as Dinosaurian. The tarsus, however, is distinct, the astragalus and calcaneum being separate.

Now it is quite possible that these animals and Staganolepis are more nearly related to the Dinosaurs than to Crocodiles; but if so, it only demonstrates that some Dinosaurs must be much more Crocodilian than we have hitherto had reason to believe. There are several modifications of the Dinosaurian skull. One specimen figured by Mr. Hulke, and referred to Iguanodon, exhibits the form of the brain-case and its central cavity, showing that the brain was remarkable for its great height, that it was compressed from side to side, and apparently distinguished into cerebrum, optic lobes, and cerebellum, placed successively behind each other, on the reptile plan, though not like any living reptile, and making no approach in shape to the brain of a bird (see Fig. 2). A portion of the base of the brain-case of a Dinosaur from the Potton sands, which has been named Craterosaurus, is similar to the same region of the skull in the New-Zealand Lizard Hatteria, but makes several approximations to the Crocodilian pattern. Another Dinosaurian skull is referred to Scelidosaurus by Professor Owen; and skulls of the Hypsilophodon have been figured by Professor

Huxley and Mr. Hulke (see Fig. 1). Now when these skulls are critically compared with those referred to Belodon, some of which may belong to Zanclodon, the resemblance of plan is sufficiently close to arrest attention; and points in which triassic skulls differ from Crocodilia are points in which they approach the Dinosauria. If the Crocodilian skull were supposed to be plastic and squeezed together from side to side, so as to become much narrower, and sufficiently elevated to make the eyes nearly vertical, then the chief point necessary to complete the Dinosaurian resemblance would be great relative enlargement of the cerebral cavity and the temporal fossæ and a reduced length of the jaw. But if instead of comparing the Dinosaur with the living Crocodile, we had taken a representative of the fossil group of Crocodiles called Teleosauria, the resemblance would have been, with such modifications as suggested, almost perfect, nor would the palate have been so entirely incomparable with the Dinosaurian palate in certain Teleosaurs as in the existing Crocodile. These resemblances, however, are probably of value merely as showing that Dinosaurs and Teleosaurs may be descended from a common stock; for as the Teleosaurs are unknown in the primary rocks, there is no reason for inferring that the one group was evolved from the other. The palate in Dinosaurs, so far as may be judged from its condition in Scelidosaurus and Hypsilophodon, finds its nearest parallel at the present day in the New-Zealand lizard Hatteria, in which the pterygoid bones have a similar form and send processes outward and backward to meet and lap along the inner processes of the quadrate bones, which articulate with the lower jaw, are similarly separated in the median line, and unite with comparatively slender palatine bones. It is difficult to estimate the importance of this and other resemblances which Dinosaurs show in the skull to Hatteria, especially since, taken as a whole, they do not counterbalance the remarkable resemblances to the Crocodilian group. Perhaps they rather indicate that the systematic place of Hatteria is nearer to Crocodiles than its earlier location among the Lizards might have suggested. The anterior nares are always placed well forward (Fig. 1), divided and almost surrounded by the premaxillary bones, much as in the Alligator. The nasal bones and frontal bones are elongated, as among Crocodiles, but it is not quite clear at present whether the frontal bone always enters into the cavity for the orbit of the eye. The frontal and parietal together contribute to form the large lateral surfaces behind the eyes, to which were attached the muscles which worked the lower jaw. At first sight this region offers some resemblance to Hatteria. The teeth vary in kind in different Dinosaurs. Perhaps the most Crocodilian type is Mega-

losaurus, for certain living Crocodiles have the lateral ridges of the teeth marked with minute serrations. Professor Huxley has shown that all Dinosaurian teeth, no matter how worn ultimately, are characterized by more or less marked serrations of the compressed margin. The teeth in front are frequently simple and conical incisors, contained in the pre-maxillary bone, which do not become worn down, because they appear to have had adapted to them a toothless pad in the lower jaw, which was hollowed out something like the beak of a parrot. Behind these, without any intervening canine tooth, so far as known forms go, succeed the molars, which in the herbivorous genera usually have their surfaces worn more or less flat. The distinction into pre-molars and molars is a character fairly marked in the Crocodilian jaw, where the canine teeth also may be detected; though, owing to the molars not usually being worn down, they do not present the modified appearance seen in Dinosaurs. The resemblances perhaps are equally close in the teeth of Lizards, where pre-molars and molars are often easily recognized, though some Lizards, like the *Cnemidophorus lacertinoides* from Mexico, show distinct incisors, pre-molars, and molar teeth with cusps, like those of mammals. Among the Reptilia, probably no part of the skeleton is of less value than the teeth for purposes of classification; and the same type, if not the exact form, is maintained in nearly allied genera. Taking the skull as a whole, and contrasting its Triassic forms with those of the Wealden beds, the differences which have developed themselves are in all cases such as would be held, in the vertebrate province, to pertain to a higher group of animals; but though in Hypsilophodon the eyes rest against hollows in the frontal bones (Fig. 1), as among some birds and many mammals, there is nothing in the skull which indicates that the Dinosauria are a transitional group, passing into either the Mammalian or Avian Class.

The vertebral column shows a good deal of variety. If Professor Owen is correct in identifying as Dinosaurs certain reptiles from the Trias of South Africa, the vertebræ may have the articular faces of the centrums as deeply biconcave as in the living Hatteria or in Ichthyosaurus. In Zanclodon the cervical vertebræ are greatly elongated, like those of a long-necked ruminant, and concave at both ends (Fig. 4). In this genus, as in Morosaurus, figured by Professor Marsh, the atlas and axis are separate bones, as in the existing crocodile, the odontoid mass of the atlas fitting firmly, however, against the front of the second vertebra. This is the more interesting because in some Wealden types, like Iguanodon, the odontoid process is anchylosed with the axis, so as to closely approximate in appearance to the condition of the axis in a bird (see Fig. 3).

The Crocodilian resemblance of the bones in Zanclodon is the more remarkable because in the Teleosaurs there is no such Crocodilian condition of the earliest neck vertebræ, but a close resemblance to the same bones in Plesiosaurus. Here, then, as in the skull, there is evidence of evolution, in so far that in later time these joints of the neck acquire the characters seen in a higher organic type. The centrums or bodies of the vertebræ, both in the neck and back, in many, if not all, of the older Dinosauria, have their articular surfaces flattened or concave; and though this condition is retained in some of the latest known representatives of the group, such as the Dinosaurs of Gosau and of the Cambridge Greensand, many other genera, such as Megalosaurus and most of the Wealden types, have the bodies of the neck vertebræ convex in front and concavely-cupped behind, as among the ruminant mammals. This is the more interesting because the character was at first supposed to indicate a distinct genus, which was named Streptospondylus. It is probably one of the characters by which the Dinosauria will hereafter be divided into family groups. It is especially remarkable, because no reptile presents the same modification, though the neck is so curiously constructed among Chelonians as to present this condition in one or two vertebræ. This reptilian resemblance is at least as strong and as important as that seen in the lower dorsal vertebræ of penguins, where the centrum is also opisthocœlous; especially as the character becomes lost in the lower dorsal region of Dinosaurs. Consequently here, too, the change which the mode of union of the vertebræ presents is best explained as a condition of evolution going on within the group, by which, as ossification became more perfect, the neck vertebræ, like some of those of the back, put on a character that is only similarly developed among mammals. In all the Dinosauria the neck vertebræ have small, short ribs, with a double articulation, formed on the Crocodilian plan, (Fig. 4); and in the dorsal region the rib rises entirely on to the neural arch, and has two distinct articular facets, the head joining the side of the neural arch, and the tubercle being connected with the transverse process (Fig. 5). In the older genera the dorsal vertebræ are moderately compressed from side to side, but in the newer types they often become more compressed, and the articulations for the rib rise higher up the neural arch, indicating an increased development of the lungs. The transverse platform of the neural arch in the region of the back, which is one of the distinctive characters of a Dinosaur, has a very bird-like appearance; but it differs from that of the Crocodile chiefly in the transverse processes being relatively shorter, and lifted higher up the sides of the neural arch to make room for the lungs. No part of the

Dinosaurian skeleton is more characteristic than the sacrum (Fig. 6), which usually consists of a number of vertebræ blended together, so as to form a strong mass, to which short ribs were attached. These vertebræ are stated to be always more than two; perhaps there may be no limitation in number. Certainly in Zanclodon there are only two sacral vertebræ united together. Thecodontosaurus, according to Professor Huxley, had three sacral vertebræ; Hylæosaurus not fewer than four; Megalosaurus and Iguanodon five. In Anoplosaurus there are six, and in Agathaumus there are said to be eight or ten sacral vertebræ. Probably two is the primitive number, as among Crocodiles. And just as Professor Huxley has analysed the chick sacrum into four true sacral elements, with dorso-lumbar elements in front and caudal elements behind, which have become blended together owing to the extension along them of the bones of the pelvis which are known as the iliac bones, so the extension of the ilium backward and forward in Dinosaurs, beyond the limits of the two original vertebræ, has caused the sacrum to increase in length, and thus to approximate in the number of bones it includes to the sacrum of a bird. But if it is bird-like at one end of the series it is crocodilian at the other; and here also we have evidence of a remarkable change going on in the skeleton of successive genera in past time, which I am inclined to regard as entirely functional and correlated with the circumstance that the earlier triassic Dinosaurs progressed in the manner of Crocodiles, while some of the later forms put so much of the energy of movement into the hind-limbs that they acquired a more or less erect mode of progression. The sacrum of Anoplosaurus is especially remarkable for the fact that its neural canal is enlarged so as to be wider than the entire centrum of a dorsal vertebra.

The tail varies in length. *Zanclodon lævis* has thirty-seven caudal vertebræ; other Dinosaurs have probably many more. In the long-tailed genera, like Lælaps, Ceteosaurus, and Macrurosaurus, the later vertebræ become elongated into a dice-box shape. Perhaps the tail is shortest in Anoplosaurus from the Cambridge Greensand, in which only eight vertebræ have been found, and probably but few more existed. Many Dinosaurs, though not all, have in the first half of the tail V-shaped bones articulated at the junction of each pair of vertebræ on the underside. Sometimes these chevron bones (see Fig. 7) are long, at others short; sometimes the V-shape becomes changed into a triangle by the articular facets uniting, as among certain lizards; occasionally they are prolonged to the end of the tail. The tail shows less modification, perhaps, than any other part of the skeleton. As among Crocodiles the

transverse processes disappear in its hinder part, and the earlier caudal vertebræ are usually massive but short (Fig. 7). There is nothing about the tail suggestive of resemblance to a bird, and the characters of the caudal vertebræ of Archæopteryx are quite different, nor would it be worth while examining how far the tail may be paralleled among the Mammalia. It is, however, right to mention that in certain Dinosaurs, which are otherwise imperfectly known, the articular ends conform to the Crocodilian pattern in being procœlous.

When the elements which form the vertebral column are freed from the matrix so as to be adapted together by their natural surfaces, they usually fall into three marked curves. First the cervical vertebræ form a curve which is convex on the under side and concave above, showing that the neck was usually arched upward. The dorsal and sacral vertebræ similarly form a curve in the opposite direction, that is to say, convex in length on its upper side, between the fore and hind limbs, indicating that the back was arched. While the tail vertebræ similarly form a curve in the reverse direction, or concave on the upper margin, and its concavity is usually so well marked as only to be intelligible on the hypothesis that the root of the tail was elevated to a considerable height above the ground. In the larger-tailed Dinosauria the depth and thickness of the tail was immense, and perhaps entirely Crocodilian in the relative proportion which it bore to the depth of the body.

The ribs in the dorsal region appear to have been long, well curved, directed outwards, and sometimes upwards, so as to enclose a large visceral cavity. They are usually compressed from side to side, and sometimes flattened above, so that the cross-section of the upper part of a rib resembles a capital T. This character is especially seen in the Dinosaurs from the Greensand of England and Gosau; and, judging from the way in which the transversely expanded neural spine of Belodon is correlated with the support of dermal armour, it seems probable that lateral stripes of dermal armour may be inferred from this condition of the dorsal ribs, especially as massive dermal plates are found in association with the remains in both those localities. The specimen of Ceteosaurus at Oxford includes a bone which Professor Phillips interpreted as the sternum. Such a bone may perhaps exist in some of the German triassic genera, but no other trace of it has been met with, and but few ribs could have been articulated to it.

The scapular arch changes but little throughout the entire group (Fig. 9). It consists of a broad rounded or quadrate coracoid, which unites with the long and flattened scapula to form the glenoid cavity which receives the head of the humerus.

The coracoid is always pierced with a foramen near to its union with the scapula. The scapula always widens at its union with the coracoid, and sometimes, as in the cretaceous genera, developes a not inconsiderable acromial process, which is absent in examples from the older rocks. In Megalosaurus the scapula and coracoid are often blended together. In many genera the scapula has a slight backward curve, and is also convex in length, so as to adapt itself to the form of the ribs. This form of scapular arch finds no parallel in the form of the bones among existing Reptilia except in the Chamæleon and Hatteria. Yet the resemblance of these bones to some in the Triassic Crocodilia is remarkably close, and the absence of clavicles rather points to a Crocodilian than a Lacertilian affinity.

The fore-limb presents nothing bird-like (Fig. 9). The humerus, as already remarked, differs from that bone in the Crocodile rather in detail than in plan, and the expansion of the head of the bone and of the distal condyles, probably has more relation to the weight of the animal to be supported than to the characters of the type from which the group was modified. The head of the bone, however, is not parallel to its distal end, and there are characteristics that would as well admit of a Lacertilian as of a Crocodilian interpretation; yet the form of the bone in most cases permits no doubt as to the ordinal group to which it belongs. The ulna and radius were placed one behind the other, more after the manner of the Lizard, perhaps, than of the Crocodile. Specimens in the British Museum show that the radius was received in a groove or depression of the ulna at its proximal end. The olecranon process at the humeral end is large (Fig. 9). The carpus has hitherto been imperfectly figured. It is represented by Professor Owen in Iguanodon in union with the ulna and radius, and appears to consist of two bones. In this genus Professor Owen has figured a remarkable spur on the inner side of the foot, thus identifying a bone which Mantell formerly regarded as a nasal horn, and which Professor Owen had subsequently interpreted as a claw phalange. The specimen is obscure, but from evidence that many Dinosaurs have five digits in the fore-limb it may not perhaps be impossible that this supposed anomalous spur may be an abnormally modified digit. The number of phalanges in the fore-limbs appears to be variable. Altogether the fore-limb is but little specialized, and might have been modified from any generalized reptilian type. Its characters have been but little discussed. Taken as a whole, it must be regarded as furnishing important evidence of reptilian affinities, which, unlike the parts of the skeleton already mentioned, change their type but little in the various genera which conserve this grade of animal organization.

The pelvis, on the other hand, is unlike that of any reptile. As is well known, the Ilium, or bone which extends along the sacral vertebræ, is in Reptiles either vertical or directed backward, though it attains its most expanded form in the Crocodiles (Fig. 11). In Birds it extends about equally before and behind the acetabulum, or cup for the articulation of the femur. In the Mammals it is directed almost entirely in front of the acetabulum. Too much importance ought not to be attached to the direction of this bone as a mark of affinity, because its direction is almost always entirely forwards in frogs, probably without any other explanation than the influence of the manner of progression of the Anura in determining the direction of its growth. Similarly we are as little justified in regarding the Avian extension of the Dinosaurian ilium as a mark of Avian affinity in these animals, as we should be in regarding the direction of the Anurous ilium as an evidence of Mammalian affinity. When the shape of the ilium in Triassic Dinosaurs is examined and compared with that of the Crocodile, the resemblance is closer than might have been anticipated. The ilium has its chief extension backward; there is a process directed downward to the ischium, and forward to the pubis. This is well seen in Zanclodon, as is proved by specimens in the Tubingen collection; and I infer by analogy that the left ilium of Thecodontosaurus figured by Professor Huxley also had its chief extension behind the acetabulum (Fig. 12). But there is no doubt that other genera, like Iguanodon (Fig. 13), had the anterior process of the ilium, which is not developed in Thecodontosaurus, extended far forward; while other genera, like the Morosaurus of Marsh (Fig. 10), show the bone to have great depth, and, if rightly interpreted, to have its chief direction inclining anteriorly. There would thus appear to have been a progressive modification of this bone, by which a reptilian form which was associated with a Reptilian mode of progression became changed for an Avian shape in animals in which the progression was birdlike. And, although I confess to doubts concerning the right reading of some of Professor Marsh's figures, it would appear that these changes of form tended slightly towards the Mammalian pattern. The ischium is essentially a Crocodilian bone; and in the Atlantosaurus or Camarasaurus figured by Professor Marsh has a shape which is Crocodilian, meets the pubis much in the same manner as in the Crocodile, and the bones appear to have a Crocodilian direction. But, on the other hand, in some other genera, such as Iguanodon, ischium and pubis are slender bones, which resemble, both in form and direction, the same elements in the Apteryx or the Emeu; and this resemblance is the more interesting since Mr. Hulke has shown that the pubis developes

a large anterior pre-pubic process, which may be considered Lizard-like or Chelonian, but is not altogether unparalleled by the small pre-pubic process of the Apteryx. Professor Marsh has described more than one remarkable modification of this type of pelvis, which appears to show that a distinctive Reptilian feature is retained, even after the bones acquired the closest possible resemblance to Avian forms and manner of arrangement. The pre-pubic process, however, might be regarded as analogous with the pre-pubic bones of Ornithosaurus and Monotremes, although in those groups it is a distinct ossification.

The hind-limb offers a nearer resemblance to that part of the skeleton in a bird, than in any other animal, and is much more bird-like than the hind-limb in any existing reptile, but its Avian characteristics have probably been over-estimated (Fig. 10). The femur, or thigh-bone (Fig. 14), is long and strong, and readily recognized by three characters: first, the depth to which its head is received into the cavity in the ilium, which usually makes the whole of the upper, or proximal end of the bone an articular surface, and renders it impossible to define the head of the bone from its shaft, because there is no constriction between them; secondly, there is almost always a slender free process, or trochanter, directed upward on the outer front margin of the bone, which appears to correspond, in part at least, to the great trochanter; and, thirdly, on the inner border of the shaft of the bone, at, or above its middle part, is another trochanter, compressed from side to side, usually called the third, and regarded as peculiarly Dinosaurian, which is nothing but the lesser trochanter of the mammalian femur somewhat differently placed. This latter conclusion is satisfactorily demonstrated by remains of a new genus from the Upper Greensand of Gosau, placed in my hands by Professor Suess. Here a strong muscular crest, which may be exactly compared to the posterior ridge between the trochanters on the human femur, sweeps down in a curve from the outer and upper margin of the hinder side of the bone to the inner trochanter. But though the aspect of the femur thus becomes Mammalian, the bone is nevertheless modified from a Crocodilian plan. If we suppose the head of the Crocodilian femur to have the apex of its triangular outline on the middle of the inner margin immensely enlarged at the expense of the anterior part, it becomes Dinosaurian. And on the middle of the inner side of the shaft of the bone the Crocodile has a trochanteroid thickening, which corresponds with the inner or 'little' trochanter of Dinosaurs; and just as in the Gosau specimens, an 'intertrochanteric' muscular ridge extends from it upward and

outward to the proximal end of the bone. Both the trochanters are sometimes wanting in American genera. In Belodon, the femur diverged but little from the shape in living Crocodiles, but its slight modifications are all in the Dinosaurian direction; and it appears to me, that, like so many other of the elements of the skeleton, the femur underwent evolution in successive genera, which caused its original somewhat Crocodilian appearance afterwards to approximate to the shape that characterizes the bone in Birds and Mammals.

The next segment of the hind-limb, consisting of the tibia and fibula, is sometimes much more Avian in its character, but differs fundamentally from this part of the bird's skeleton in having the fibula better developed, so that it extends down to articulate with the tarsus, while in birds it tapers away to a needle point, and never is inserted into the tarsus at all. The Avian character is, therefore, to be found in the tibia only. And here it is limited to two points. First, the development of a strong anterior crest, which is directed forward and outward, so as often to extend in front of the fibula, is a Dinosaurian character met with, to some extent, among Birds, but quite as well marked in Mammals. Secondly, the shape of the distal end of the bone is bird-like; but that form is found in no adult bird, and is only to be detected in the young bird before the tarsus has become blended with it; so that while it might go to show, perhaps, that Birds are descended from a common stock with Dinosaurs, it would be misleading to regard it as altogether Avian, since the character is lost in the adult bird's skeleton. It is only in such genera as Cœlosaurus (Fig. 16), Megalosaurus, and Iguanodon, that the tibia has a shape that suggests the bird; while in Hylæosaurus (Fig. 15), it is, if not Crocodilian, more suggestive of a crocodile than a bird; and, so far as can be inferred from figures of the Colorado type named Morosaurus (Fig. 10), the tibia in that genus is altogether Reptilian. But when the tarsus, or rather the astragalus, is closely applied to the tibia, as in Megalosaurus, Pœcilopleuron, Lælaps, or Iguanodon, it gives the bone a resemblance to the bird which is almost convincing, since the parallel extends to nearly every detail. The character, however, is shorn of much of its importance, when we remember that there are many Dinosaurs in which there is an os calcis, or heel-bone, placed side by side with the astragalus (Fig. 17); and that in other genera like Morosaurus, the astragalus was not an Avian conformation, so that it is not a general characteristic of the order, and, therefore, must have undergone change in the group. It seems, hence, more reasonable to infer that the Avian type of the bone is more likely to be a consequence of the hind-limbs being used for progression

in certain genera, after the manner of birds, than that what is among existing animals a class-characteristic, should disappear, especially as Morosaurus is one of those genera in which some of the vital organs made a remarkable approximation to the bird-type. Morosaurus had two rows of tarsal bones. The metatarsals are three, as in Laosaurus, four, as in Scelidosaurus, or five in number, as in Morosaurus; but they are never anchylosed into one mass, as in Birds. The number of phalanges increases in the outer digits as in Birds and Reptiles. The claw phalanges are sometimes compressed from side to side as in Birds, sometimes from above downward, as in Reptiles.

This survey of the osteology of the Dinosauria leads us, I think, to conclude that whatever the group eventually became, it originated in a close family relationship with the Crocodilia; and that plan, which was never entirely obliterated, underwent a development in most parts of the skeleton, more perfect than is known to have occurred in any other group of animals. But this series of changes in the skeleton did not convert the crocodile into a bird or a mammal, or make it anything but a near ally of the crocodiles, which, owing to the influence of conditions of existence, came to simulate birds in some parts of the skeleton and mammals in other parts. But it is impossible to believe that these modifications of the hard parts of the animal went on without the soft vital organs changing also; and all analogy would suggest that the change was progressive, so that the vital organs of the Crocodile may have greatly altered. But whether the progress extended so far that certain Dinosaurs became eventually changed into birds in all essentials of organization and in some parts of the skeleton, while others approximated to mammals, is a speculative problem, attractive in its plausible simplicity, with which facts do not yet enable us to deal in a satisfactory way; though it must be admitted, they give some support to such an hypothesis.

A satisfactory classification of the Dinosauria can hardly be made until we know far more of the fossil representatives of the group, more of the extinct reptiles of South Africa, of the Labyrinthodontia, of the Ichthyosauria, and of the Ornithosauria, for with all these animals Dinosaurs show some evidences of affinity. The higher Labyrinthodonts, which, in some unexplained reverence for formulæ, have got themselves included in the Amphibia notwithstanding the characters of their skull and axial skeleton, certainly closely approach Crocodiles, and therefore Dinosaurs and Ichthyosaurs. The Ichthyosaurs are perhaps such a group as the Dinosaurs might have become under aquatic conditions of existence; for although the resemblances of Ichthyosaurs to ordinary Dino-

saurs are of the most slender kind, their resemblances to the triassic Crocodilia are more important, and suggest such a view as a possibility.

Professor Cope divided the Dinosauria into three groups. The first, Symphypoda, comprises Compsognathus from the Solenhofen Slate, and Ornithotarsus from the New Jersey Greensand. The second group, Goniopoda, in which the tarsal bones embrace the tibia, includes Megalosaurus and Iguanodon. While the third group, called Orthopoda, is represented by Scelidosaurus, and comprises Dinosaurs in which the proximal tarsal bones are separate, and do not embrace the tibia. Professor Huxley has disputed the value of this division, and believing Compsognathus to be a type outside the limits of the Dinosauria, has united the two groups together under the name Ornithoscelida. But seeing that the proximal tarsal bones are united with the tibia after the manner of birds in some Ornithosaurs, while in other genera they always remain separate, it seems probable that the Dinosauria might naturally include Compsognathus. Professor Huxley has subdivided ordinary Dinosaurs into three families, distinguished by their teeth and other characters. They are named from typical genera Megalosauridæ, Scelidosauridæ, and Iguanodontidæ. But though these are the best marked Dinosaurian groups in England, there are many Dinosaurs that it would be difficult to place with these. Finally, Professor Marsh proposed a new sub-order, Sauropoda, for the gigantic Dinosaurs described by himself and Professor Cope from Wyoming and Colorado. I may perhaps be permitted to state that on very slender evidence I ventured to predict the existence of this group nearly ten years ago. It happened that I was studying Dinosaurs, and arrived at views about the skull which led me to examine a bone in the British Museum, long previously regarded as the tympanic or quadrate bone of Iguanodon. It appeared to be an imperfect dorsal vertebra, and as there was another and earlier vertebra in the collection of a like character, I named the form Ornithopsis Hulkii, in honour of Mr. Hulke. The genus was named Ornithopsis on account of a bird-likeness, in nothing more remarkable than in the way in which the bodies of the vertebræ were excavated, as in Birds and Pterodactyles for the reception of an air-cell prolonged from the lung. Professor Cope has shown by his admirable descriptions that this is the most remarkable character of the great Colorado Dinosaurs, such as Camarasaurus, which differs from Ornithopsis in minor generic characters. The type is truly Dinosaurian, and therefore profoundly interesting as showing that animals which put on so many avian characters in their bones, acquired lungs only comparable in complexity and plan to those of Ptero-

dactyles and Birds. So that we may say that this group which I had formerly in mind when using the name Ceteosauria demonstrates that certain Dinosaurs approximate to both those groups, and may have possessed the vital organization of a bird. Hence Dinosaurs are to Crocodiles what Birds are said by evolutionists to be to Lizards.

Thus I have endeavoured to bring together not merely strings of names of animals in which the beautiful museums of Germany and Vienna are rich, but have tried, by a touch of the scientific wand, to make them unfold their structure and history, and live again, not as mere dry bones, but clothed with a power of engendering truths.

EXPLANATION OF PLATE II.

FIG. 1. Right side of a generalized Dinosauriam skull, restored chiefly from a figure of Hypsilophodon, by Professor Huxley, and partly from Scelidosaurus and other materials.

FIG. 2. Outline of the brain-cavity of Iguanodon in the middle-line of the skull, after Mr. Hulke; the large size and upward extension of the optic lobes is more remarkable than in Teleosaurus, but the form of the brain-cavity is most like that of Ichthyosaurus.

FIG. 3. Axis of Iguanodon, from the Wealden Beds, showing the odontoid process and the two tubercles for the rib.

FIG. 4. Early cervical vertebra, with cervical rib of Zanclodon, from the Trias of Württemberg.

FIG. 5. Dorsal vertebra of Iguanodon, showing that the attachments of the rib are entirely on the neural arch.

FIG. 6. Sacrum of Iguanodon, seen from the visceral surface, consisting of five vertebræ, anchylosed together.

FIG. 7. Mid-caudal vertebra of Iguanodon, showing the long neural spine and large chevron bone.

FIG. 8. Centrum of vertebra of Ornithopsis, showing the cavity for the air-cell which excavates the body of the vertebra.

FIG. 9. Fore-limb of Morosaurus, after Professor Marsh.

FIG. 10. Hind limb and pelvis of Morosaurus, after Professor Marsh.

FIG. 11. Ilium of Alligator. *a. p.* The anterior process.

FIG. 12. Ilium of Thecodontosaurus, placed for comparison with the Alligator. *a. p.* The anterior process.

FIG. 13. Ilium of Iguanodon, after Owen and Huxley. The Ilium of Megolosaurus is intermediate between this type and that of Morosaurus, shown in fig. 10. *a. p.* The anterior process.

FIG. 14. Femur of Iguanodon, after Professor Owen.

FIG. 15. Tibia of Hylæosaurus, after Mr. Hulke.

FIG. 16. Tibia of Cœlosaurus, after Professor Leidy.

FIG. 17. Distal end of Tibia and Fibula in Ornithotarsus, after Professor Cope, showing their union with the astragalus and calcaneum.

REVIEWS.

PALÆONTOLOGY.*

PROFESSOR NICHOLSON has published so many text-books and manuals on various subjects of Natural History, that in a very short time, if he continues in the same fashion, his works of this kind will make a small library of themselves. His latest production is a second edition of his *Manual of Palæontology*, the first issue of which took place just seven years ago, and this has been so thoroughly revised and so greatly augmented that, as he himself tells us in his preface, it may be considered practically a new book, although of course in the general treatment of the subject the author has followed much the same lines that were laid down in his former edition. The last section of the first edition, treating of Palæontology from a historical or stratigraphical point of view, has been expanded by the author into a separate book, having the title of *The Ancient Life-History of the Earth*, in which the subject is developed in much more detail than could be compatible with the plan of the present work, and hence the author has thought it best to omit this section altogether. Thus without diminishing the usefulness of his book, he has been enabled to avail himself of a considerable amount of space for the more complete exposition of his primary subject.

This consists in a regular, systematic treatment of the fossil forms hitherto discovered in the strata of the Earth's crust, and it must be confessed that Dr. Nicholson has been most successful in carrying it out. Commencing with the Sponges, as the lowest types, he proceeds upwards through the various classes of the animal kingdom, the fossil remains of animals naturally occupying the greater part of the work; and in all cases the descriptions of the fossil forms are preceded by a short introductory essay on the characters of the different groups as manifested at the present day, a most important element in the philosophical conception of the subject, as too many palæontologists are inclined to forget that in the interpretation of fossils they must be guided solely by considerations drawn from existing species.

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* *A Manual of Palæontology for the use of Students, with a General Introduction on the Principles of Palæontology.* By Henry Alleyne Nicholson, M.D., &c. Second edition, 2 vols. 8vo. Edinburgh and London: Blackwood and Sons. 1879.

Palæobotany, or the palæontology of plants, is treated of rather cursorily in the last few chapters of the book; and there, also, the author has changed his plan. Instead of attempting to give a systematic revision of the fossil forms of plants, he has employed the chronological mode of treatment, which perhaps, considering all things, is the best that can be adopted for conveying a general idea of this department of the subject. The fact is, that from our imperfect knowledge of fossil plants and the very nature of those organisms, it would be almost impossible to produce a good picture of this department of palæontology on a systematic basis within moderate limits, and the interest attaching to the geological history of plants is generally derived, less from the consideration of the individual types than of their combinations to form Floras, which must necessarily be treated in connection with the strata in which they occur.

It would be useless, and indeed most uninteresting, to the reader, if we were to attempt anything in the shape of an analysis of the chapters of Dr. Nicholson's work devoted to palæozoology. It will be sufficient to say, in general terms, that the book has evidently been prepared with the greatest care, and that, on testing various parts of it, we find that the author has embodied in his statements the results of nearly all recent researches in all the departments of the subject. This is especially observable in the second volume, which chiefly deals with the Vertebrata; here we find that some of the latest contributions to the history of extinct reptiles, birds, and mammals, have been made use of by the author. In his preface, indeed, he tells us that owing to some delay in publication, after the preparation of the greater part of the book, and indeed after a considerable portion of it was in print, he has been unable to avail himself of certain important memoirs which have appeared in the interim, such as Zittel's valuable systematic works on Fossil Sponges, Professor Möbius' treatise on *Eozoon canadense*, Mr. Moseley's researches on the Stylasteridæ, and several others which have appeared chiefly in the course of the year 1879. Such causes of regret, however, are almost inseparable from the production of a work of this magnitude; and students of palæontology have every cause to be grateful to Dr. Nicholson for the labour which he has expended in the elaboration of this Hand-book.*

With the view of rendering his book as complete as possible, the author prefixes to the systematic part of it, a general introduction, intended to

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* Although we have thought it unnecessary to attempt any criticism of Dr. Nicholson's work, we may call attention to the fact that Dr. Traquair has written to various periodicals, calling attention to a misstatement of his unpublished views as to the systematic position of certain Fishes (Vol. II., pp. 134 and 138). Dr. Nicholson has in consequence sent out a statement, which may be pasted into the book as an erratum, to the effect that, 'The reader will kindly delete "Platysomidæ" from the list of *sub-orders* of Ganoids, and place these fishes next after the Palæoniscidæ as a *family* of Lepidosteidæ. . . . . Dr. Traquair holds that the Platysomidæ constitute a *family* very distinct from the Pycnodontidæ, but closely allied to Palæoniscidæ, and that the position of both Palæoniscidæ and Platysomidæ is rather in the sub-order Acipenseroidei.'

'Dr. Nicholson's mistake,' says Dr. Traquair, 'is evidently due to his having had only a very hurried glance over my proof-sheets, and that only on a single occasion.'

explain to the reader the conditions under which fossils are presented to his consideration, and the consequences to be drawn from their study. In successive chapters he deals with the nature of fossils and rocks, the characters of the sedimentary rocks, their chronological succession, and the application of palæontology to the elucidation of the latter, the causes of imperfections in the palæontological record, and the conclusions that may be drawn from fossils, winding up with a chapter on the classification of the animal kingdom and the succession and progression of organic types. All these subjects, many of which are rather difficult to handle, are well treated; and the student who masters these chapters will approach his practical studies with a better intellectual foundation than can be boasted of by many professed palæontologists. A full index and a good glossary of terms employed will add greatly to the usefulness of the book.

We have yet to say a few words upon the way in which these volumes are got up. In type and paper they leave nothing to be desired, and the woodcut illustrations, most of which are original, and the work of Mr. Charles Berjeau, are really beautifully executed. The book is in fact almost what our neighbours across the Channel would call *un ouvrage de luxe*. But we fear that these very characters, which cannot but excite our admiration and approval, must raise the cost of the work to an extent which will practically cut it off from the use of the great majority of the students for whose behoof it is said to have been prepared.

TABULATE CORALS.*

IN the preface to his *Manual of Palæontology*, Professor Nicholson remarks that he would have considerably modified the section dealing with the so-called 'Tabulate Corals,' had his investigations into the structure and relationships of these fossils been completed in time. The result of these researches is now before us in the form of a magnificent octavo volume, which we have no hesitation in pronouncing the best of all the author's numerous works.

The group of Tabulate Corals (*Madreporaria Tabulata*) was founded by MM. Milne-Edwards and Haime in the introduction to their splendid monograph of the British Fossil Corals, published by the Palæontographical Society in 1850. It was established for the reception of a number of rather problematical stony structures, ranging in time from the Silurian period to the present day, and exhibiting a considerable diversity of character, but agreeing in having well-developed walls, and the visceral cavities of the individual polypes divided into a series of chambers, one above the other, by complete diaphragms or transverse floors. Added to these characters was the complete absence, or rudimentary condition of the septal system, which was never represented by anything more than a few 'trabeculæ' projecting into the visceral chambers. The principal living forms referred to this

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* *On the Structure and Affinities of the Tabulate Corals of the Palæozoic Period, with critical descriptions of Illustrative Species.* By H. Alleyne Nicholson, M.D., &c. 8vo. London and Edinburgh: Blackwood and Sons. 1879.

group by M. Milne-Edwards, belonged to the genera *Millepora*, *Heliopora* (representing the family Milleporidæ), *Pocillopora* (referred to the Favositidæ), and *Seriatopora* (the type of the Seriatoporidæ); and the fossil forms were more or less closely associated with these in accordance with the resemblances apparently presented by the respective polyparies. The great majority of the fossils were from palæozoic deposits, and the well-known forms of *Favosites* and *Halysites* may serve as typical examples of the group.

Although MM. Milne-Edwards and Haime established the section Madreporaria Tabulata for the convenience of having some group to which to refer a considerable series of fossils with which they were obliged to deal, it is very clear that they felt by no means convinced that it was a sound zoological group; and as early as the year 1860, we find M. Milne-Edwards himself, in the third volume of his *Histoire Naturelle des Coralliaires* (p. 223), remarking that 'according to recent observations made by M. Agassiz upon the Millepores, it is probable that it will have to undergo great alterations, or perhaps be placed entirely in another class of the animal kingdom.' This passage alludes to the discovery by Agassiz of the Hydrozoal nature of *Millepora*, which has since been amply confirmed by Mr. Moseley during the voyage of the *Challenger*, and by Professor P. Martin Duncan from the researches made many years ago by General Nelson at Bermuda. Further investigations have shown that notwithstanding the correctness of Professor Agassiz's observations, the removal of all the Tabulate Corals to the Hydrozoa, as suggested by him and supported by some other naturalists, would have been a mistake, the recent genus *Pocillopora*, especially, proving to be a true Zoantharian allied to the well-known Oculinidæ. The morphological importance of the 'tabulæ,' or transverse floors, the presence of which constituted the chief bond of union between the members of the group, was also shown to have been overrated, as similar structures occur in a good many genera of undoubted Zoantharian corals. The combined researches of palæontologists in fact showed pretty clearly that the group would never be removed 'en entier,' as suggested by M. Milne-Edwards, to any class of the animal kingdom.

Professor Nicholson enters in considerable detail into the history of the section Tabulata, which he shows clearly must be 'broken up and undergo redistribution.' The performance of this task is, however, a matter of no small difficulty, the great majority of the species referred to in this group being old Palæozoic fossils, with no very distinct relationships to any existing forms. Our author is inclined to recognize about twelve distinct groups of these corals, the affinities of which he discusses (pp. 12–29). The Milleporidæ, here greatly reduced in compass, must, as we have seen, be referred to the Hydrozoa in the vicinity of *Hydractinia;* and the Pocilloporidæ have been shown by Professor Verrill's researches upon the animal of *Pocillopora* to be Zoantharians allied to the Oculinidæ *Seriatopora*, a recent coral, and with Milne-Edwards the type of a distinct family, is regarded as so closely related to *Pocillopora*, that it must also be transferred to the same neighbourhood. The Favositidæ (Honey-comb Corals) which constitute by far the greater part of the section as proposed by Milne-Edwards, are pretty generally regarded as true Zoantharia, to which the Columnariadæ and Syringoporidæ also probably belong, although their precise position is much more

doubtful. *Heliopora*, the type of the Helioporidæ, has been proved by Mr. Moseley to belong not to the Zoantharia, but to the Alcyonaria, and it carries with it the fossil *Heliolites*, with which, on the other hand, the 'Chain Corals' (Halysitidæ), the Tetradiidæ, and the Theciidæ, and, perhaps, also a portion of the Chætetidæ, are considered by Professor Nicholson to be nearly allied, so that the members of these groups will probably have to be placed among the Alcyonarian polypes, or occupy a position on the boundary line between the two great groups of Actinozoa. The curious Silurian genus, *Labechia*, has apparently baffled all the efforts of our author to give it a 'local habitation' in the system. The genus *Aulopora* and its allies, constituting Milne-Edwards' sub-order of Zoantharia Tubulosa, are noticed by Professor Nicholson as having been considered to be founded upon young colonies of *Syringopora*, an opinion in which he does not share; but he abstains from assigning them to any definite place in the system.

It will be seen from the preceding statements that our author is inclined altogether to abolish the Tabulate Corals as a group; and further, that in some cases he is not inclined to accept the family groups proposed by his predecessors. The portion of his book, following the summary of general systematic results, from which the foregoing particulars have been derived, is devoted to the detailed description of the Palæozoic genera and many species constituting the different groups formerly referred to the sub-order. It is impossible to overlook the many signs of the most careful work displayed in this portion of Dr. Nicholson's book; and although, as we have seen, he is compelled by the very nature of the objects of his study to leave many points in a state of uncertainty, which, indeed, may perhaps never be cleared up, he may certainly 'lay the flattering unction to his soul' that in his present volume he has made our knowledge of these puzzling organisms take a great step forward.

In the matter of illustrations, also, we are here in a condition of magnificent luxury. Scattered through the text are numerous woodcuts, some of them the same as those illustrating the chapter on Fossil Corals in the author's *Manual*, others original and prepared specially for the present work, but all excellent. In addition to these, we have fifteen beautifully executed plates, exhibiting magnified sections and other details of the Corals described. The figures on these plates, like those on wood, are all from the author's drawings, and reproduced by Mr. Berjeau, upon whom they certainly reflect the greatest credit.

SIBERIA.*

IN *Frozen Asia* we have an extremely interesting account of a country with which most of us are entirely unacquainted; and Mr. Eden has supplied a brief, but in its way very complete sketch of this territory. After giving in the first two chapters some account of the geographical

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* *Frozen Asia; a Sketch of Modern Siberia; Together with an Account of the Native Tribes inhabiting that Region.* By Charles H. Eden, F.R.G.S. 8vo. London. Society for Promoting Christian Knowledge. 1879.

features of the country, in the third he presents us with a short summary of the Geology of Siberia, for which, however, he states that he is indebted to Mr. W. W. Waddington, of Brazenose College. To this succeeds a chapter on Mineralogy, which might with advantage have been extended to greater length, considering the vast mineral resources of the country, but as these resources are far from being developed, it would perhaps be hardly fair to complain of the author's brevity in this instance. We may, however, remind the author, that malachite (p. 55) is carbonate and not oxide of copper. The chapter on the Fauna of Siberia is of particular interest, the account of the discovery of remains of the mammoth especially being compiled with no little skill. Curiously enough, the fur-bearing character of Siberia is scarcely mentioned, and the sable does not even make its appearance in the list of Siberian mammals. Of the Flora we hear very little. Perhaps there is little to tell, except that 'enough wheat could easily be raised to supply the entire European market,' a fact which may be thought worthy of notice at the present time. Only two pages are devoted to climate, of the rigour of which we gain some idea from the fact that at Yakutsk, 'the coldest city in the world,' the mercury 'remains congealed for two, and sometimes three months in the year.' Concerning the native races and 'folk-lore,' we have upwards of a hundred pages. This part of the book is perhaps the most interesting in the volume, and though but a compilation from the writings of other authors, contains many facts which must prove new to the general reader. The volume concludes with an account of recent explorations down to the time of Professor Nordenskiöld's latest expedition, and is illustrated with a map of Siberia, very nicely executed, by Stanford. The book is in every particular a very pleasant and readable one, and deserves to meet with favour at the hands of the public.

METALLIFEROUS MINERALS AND MINING.*

THE author states in his preface that it has been his design to describe in a concise and systematic manner the conditions under which metals and metalliferous ores occur in various parts of the world. He also expresses a hope that such descriptions may serve, in the first place, to explain, to some extent, the origin of ore deposits, and, secondly, by defining the zones occupied by the ores of the different metals, to lessen the amount of risk with which metalliferous mining is invariably attended. He further hopes that the figures and other data which he furnishes may have the effect of more clearly defining the conditions resulting in successful mining enterprise.

The volume, which extends over nearly 450 octavo pages, is illustrated with numerous woodcuts, for the drawings for which the author expresses his obligations to his son; and although among these we recognize some

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* *A Treatise on Metalliferous Minerals and Mining.* By D. C. Davies, F.G.S., Mining Engineer, Examiner of Mines and Collieries, Member of the Geologists' Association of London, Honorary Member of the Natural Science Society of Chester and Wrexham, &c. Author of a *Treatise on Slate and Slate Quarrying*, &c. London: Lockwood & Co., 1880.

with which we have long been familiar, they are, as a whole, not only well drawn, but also judiciously selected for the purposes of illustration.

There is throughout this work evidence of much patient compilation, and it undoubtedly contains a considerable amount of useful information. It is, however, to be regretted that sufficient care has not been exercised in the exclusion of error, and that when generalization has been attempted it becomes obvious that the author does not possess a sufficient grasp of the subjects of which he treats.

A list of such inaccuracies would exceed the limits of our space, but a few only of those which have been observed may be cited as examples.

It is stated (p. 79) that 'all the gold-bearing rocks lie below the Carboniferous group,' whereas it is well known that the majority of the rocks of the gold regions of California are Jurassic.

We are informed (p. 113) that 'the presence of silver in lodes or strata is not observed in beds newer than the Cambrian limestone.' All who possess a competent acquaintance with such subjects are, however, aware that the Great Comstock Lode of Nevada, which since its discovery some twenty years ago, has produced silver to the value of 40,000,000*l.* is enclosed within walls of undoubted Tertiary age, and that the vein itself is probably not older than the Pliocene period.

With regard to lead ore it is stated (p. 236) that its highest horizon 'is found in the Carboniferous Limestone, this horizon being divisible into two zones; one in the pale-coloured massive limestones near the base of the series, and the other in the limestones and grits near the summit.' The annual production of 40,000 tons of lead ore from the Bunter sandstone of the Düren and Commern districts in Germany is certainly a somewhat remarkable exception to this generalization.

We are taught (p. 280) that 'the geological horizon of the ores of mercury ranges from the summit of the Lower Cambrian rocks to the base of the Llandeilo beds of the Cambro-Silurian strata.' Is Mr. Davies aware that the highly productive quicksilver mine of New Almaden in California, and several others in that country, occur in rocks of Cretaceous age?

Turning from the distribution of metalliferous minerals to the statistics of their production, we still find inaccuracies, but space permits us to mention only two of them. At p. 121 the annual production of copper in Spain is stated to be about 6000 tons, whereas two Spanish mines alone produced above 20,000 tons of that metal during the year 1877. Again (p. 197) the annual production of lead in Belgium is estimated at 700 tons; reliable statistics show that the production of that country in 1876 amounted to no less than 6973 tons of metallic lead.

It will be seen from the following observations on the rocks of Cornwall, that many of the opinions brought forward differ materially from those accepted by geologists. At p. 128 when speaking of these rocks the author states:—'In maps they are all included as Devonian, which is, I think, with all deference to other observers, a mistake. My own interpretation of the ages of the strata I have just described is this:—The granitic masses belong to the Laurentian or the base of the Cambrian, the hornblende slates with the serpentine, and porphyries, to the Cambro-Silurian, the

argillaceous slates to the Silurian, passing gradually in their upper portion into the Devonian.'

In going through this volume, one cannot but sympathize with its author, who states (p. 397) that he feels ashamed when he thinks 'how German mining engineers may read the reports of some of our mine captains and experts on mineral properties.' We would add that we are by no means satisfied that the opinion of foreigners, with regard to English mining literature, will be materially improved by a perusal of the book before us. It is, however, probable that the information vouchsafed (p. 417), namely, that 'potash is potassium mixed with varying proportions of other substances,' will be new to them.

ROUGH WAYS MADE SMOOTH.*

THIS is another of the volumes of interesting essays for which Mr. Proctor is becoming famous, there being few authors gifted with his wondrous power of making interesting and instructive articles out of some of the most difficult branches of science. Like most of the preceding volumes, *Rough Ways made Smooth*, is essentially a collection of some of the numerous articles contributed by him to the magazines during the last few years. We note, however, that many of them have been revised and amended so as to render them more suitable for their present purpose. The present volume commences with an essay on the 'Sun's Corona and his Spots,' in which the author shows that the theory that the corona varies in size directly as the number of spots, is without adequate basis, although several of those who have devoted much attention to this subject were led to suppose that it did. The second essay is on 'Sun-spots and Commercial Panics,' and is devoted to showing the fallacy of the idea that sun-spots rule the commercial morality of civilized nations. The idea of a possible connection between sun-spots and commercial panics is founded on one of those partial coincidences which are so fascinating to the minds of the quasi-scientific, or to even *savants*, when they sally out of their own domains into less familiar regions.

The third essay, 'New Planets near the Sun,' deals in a popular manner with the observations of Professors Watson and Swift during the eclipse of July 1878. The fifth and sixth essays deal with the Moon, and have special reference to its past history and the supposed new crater. There are one or two errors in these, not so much on the part of the author, as on the part of those whose opinions are quoted. The early history of the Moon, like the early history of the Earth, must be discussed by one having the combined resources of chemistry and mathematics at his command. Any discussion by one who is purely a chemist, or purely a mathematician, must inevitably be vitiated by errors due to an imperfect grasp of the chemical or mathematical side of the problem. In several places, Professor Newcomb's opinion is quoted on selenographical subjects, although the experience of that eminent astronomer must be most limited in these matters. Essays seven and eight

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* *Rough Ways made Smooth.* By Richard A. Proctor. 8vo. London: Chatto and Windus. 1880.

deal with the meteors of the great shower of November, and those which seem associated with the orbit of Biela's comet. The meteor-shower which it was anticipated would be seen when the Earth passed nearest to the orbit of the comet, was not seen, either in November 1878 or November—December, 1879.

The remainder of the volume is devoted to essays of less strictly scientific nature, but in most cases of most interesting character. Those on 'Artificial Somnambulism,' 'Hereditary Traits,' and 'Mechanical Chess-players,' are especially well worth reading. On the whole, like most of Mr. Proctor's books, it is one which is far more easily taken up than laid down.

ERASMUS DARWIN.*

THE student of English books dating back some thirty or forty years and upwards has doubtless often met with fine if rather magniloquent verses quoted from a work called the *Botanic Garden*. This was a didactic poem of no small merit, in whatever light we look at it. Published originally in 1790 and 1791, its author was Dr. Erasmus Darwin, of Lichfield, a man of considerable repute in his day, and who would have occupied a far higher niche in the temple of Fame if his contemporaries had been in the least degree capable of appreciating his qualities. As most naturalists have long been aware, this Dr. Darwin was the originator of a conception of organized nature on the basis of evolution, which met with but contemptuous treatment from the author's countrymen. He has also a claim on our gratitude as having been the grandfather of Charles Darwin, whose influence upon the progress of Natural History has probably been greater than that of any other writer since the days of Linnæus.

A short note on his grandfather's biological views inserted by Mr. Darwin in the later editions of the *Origin of Species* excited the curiosity of a German *savant*, Dr. Ernst Krause, to know something more of the opinions entertained by Erasmus Darwin; and the result of a careful study of the writings of the latter on the part of Dr. Krause, was the publication in *Kosmos* of February last of a biographical and critical essay, a translation of the latter part of which, preceded by a biographical notice from his own hand, is now given to the public by Mr. Darwin.

Dr. Krause speaks of Erasmus Darwin as follows:—'This man, equally eminent as philanthropist, physician, naturalist, philosopher, and poet, is far less known and valued by posterity than he deserves, in comparison with other persons who occupy a similar rank. It is true that what is perhaps the most important of his many-sided endowments, namely, his broad view of the philosophy of nature, was not intelligible to his contemporaries; it is only now, after the lapse of a hundred years, that by the labours of one of his descendants we are in a position to estimate at its true value the wonderful perceptivity, amounting almost to divination, that he displayed in the

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* *Erasmus Darwin.* By Ernst Krause. Translated from the German by W. S. Dallas. With a preliminary notice by Charles Darwin. Small 8vo. London, John Murray, 1879.

domain of biology. For in him we find the same indefatigable spirit of research, and almost the same biological tendency, as in his grandson; and we might, not without justice, assert that the latter has succeeded to an intellectual inheritance, and carried out a programme sketched forth and left behind by his grandfather.'

'But, at the same time, we remark a material difference in their interpretation of nature. The elder Darwin was a Lamarckian, or, more properly, Jean Lamarck was a Darwinian of the older school, for he has only carried out further the ideas of Erasmus Darwin, and it is to Darwin therefore that the credit is due of having first established a complete system of the theory of evolution.' Clearly such a man as this deserves to be rescued from the comparative oblivion into which he had fallen, and we are glad to see that two writers have in this same year tried to do justice to this English worthy.

It is hardly necessary to say that the life of Erasmus Darwin as a successful physician in a provincial town passed without any striking incidents. What is to be told, however, is told here by Mr. Darwin in an exceedingly pleasant style, and he naturally devotes his attention rather to the delineation of his grandfather's character than to the thankless task of giving full details of a somewhat uneventful life. Nevertheless, the few incidents narrated, and especially the quotations given from letters, are full of interest for those who like to realize as far as possible the modes of life and thought prevalent at a time so near our own, and yet so widely separated from us.

Erasmus Darwin was descended from a family of landed gentry in Lincolnshire, and was born on the 12th of December, 1731, at Elston Hall, in Nottinghamshire. He early displayed a great fondness for poetry, and also for mechanical pursuits, both of which tastes he preserved to the end of his life; and when very young, according to his elder brother, Robert, he used to show little experiments in electricity with a rude apparatus he then invented with a bottle. In 1750 he was entered at St. John's College, Cambridge, and took a respectable degree in that university in 1754. In the autumn of the latter year he went to Edinburgh to study medicine, returned to Cambridge in 1755 to take his degree of Bachelor of Medicine, then went again to Edinburgh, whence he returned in September, 1756, and settled as a physician in Nottingham. Being unsuccessful in that city, he removed in two or three months to Lichfield, where, owing to the reputation made for him by two or three successful cases, he speedily got into good practice. At Lichfield he remained for twenty-five years, and then removed to Derby, where he died on April 18, 1802. Dr. Darwin was twice married, first to a Miss Howard, whom he lost after thirteen years of married life, and secondly to a widow lady, for whom he appears to have entertained a strong passion even during the life of her first husband, and who survived him.

Of his grandfather's character Mr. Darwin speaks very unreservedly, but on the whole, sums up, and justly, in his favour. As he says, 'There is, perhaps, no safer test of a man's real character than that of his long-continued friendship with good and able men.' Darwin's intimate and almost life-long friends were such men as Josiah Wedgwood, Keir, the chemist, Day, the author of *Sandford and Merton* (are any of the rising generation, we wonder, acquainted with Harry, and Tommy, and that wonderful Mr. Barlow?),

Boulton, and Watt, the engineers, and Mr. Edgeworth. He appears to have been incessantly active, kindly, although sometimes sarcastic, liberal in his practice, and very free from what is usually considered as one of the weaknesses of a poet, vanity. His feelings towards his children have been represented by his female biographer, Miss Seward, as not of the most amiable character; and some of his letters to them show a curious coldness: but Mr. Darwin proves clearly, indeed from that lady's own admission, that there was no truth in the most repulsive of her stories, and he accounts for her ready acceptance of so much that told to the disadvantage of Dr. Darwin, by the motive of disappointed affection, the lady having, it appears, manifested a strong desire to marry the doctor after the decease of his first wife. After his death she probably thought that a little spite could do him no harm, while it would certainly be a stab for her successful rival; and it would appear that Mr. Darwin's father was in possession of documents connected with the doctor's relations with Miss Seward, which he thought it would be unpleasant for her to have published.

What Mr. Darwin modestly calls his *Preliminary Notice* to the translation from Dr. Krause's essay occupies about three-fifths of the little volume that he has published in commemoration of his grandfather, and we fear that we have followed his example in the present notice. We, have, however, already indicated in general terms, borrowed from Dr. Krause's essay, what was the character of Dr. Darwin's philosophical work, and the essay on his scientific labours is even in the original so condensed that we could hardly do justice to it without transferring the greater part to our pages. 'Almost every single work of the younger Darwin,' says Dr. Krause, 'may be paralleled by at least a chapter in the works of his ancestor: the mystery of heredity, adaptation, the protective arrangements of animals and plants, sexual selection, insectivorous plants, and the analysis of the emotions and sociological impulses, nay, even the studies on infants are to be found already discussed in the writings of the elder Darwin.' It is to be remarked, however, that Dr. Darwin nowhere gives his ideas on the nature and evolution of organisms in a connected form, but the arguments and details are scattered profusely through the notes appended to his various didactic poems, and only partially brought together more closely in some parts of his great prose work, the *Zoonomia*. But even in these scattered notices we recognize, as indeed is remarked by Dr. Krause, the most wonderful resemblances between the elder Darwin and his still more distinguished descendant. In both we see the same philosophical breadth of view, combined with the same extraordinary power of grasping and bringing together an immense mass of details from the most varied sources to support and illustrate the argument under discussion—in fact, the same qualities which most strike us in Mr. Darwin's work are the most prominent characteristics of his grandfather's, and their exercise led both to approximately the same result. That is to say, Erasmus Darwin, equally with Charles Darwin, arrived evidently at a belief in the origin of the diversity of organized forms by a process of evolution one from the other, but the former regarded this process as brought about by internal impulses, at least semi-conscious, rather than by the action of external conditions giving rise to a process of natural selection under the struggle for existence.

EVOLUTION, OLD AND NEW.*

DR. KRAUSE, in the concluding paragraph of his essay on the works of Erasmus Darwin, says of his system that 'to wish to revive it at the present day, as has been actually seriously attempted, shows a weakness of thought and a mental anachronism which no one can envy.' This anachronism has been committed by Mr. Samuel Butler in a very interesting little volume now before us, and it is doubtless to this, which appeared while his own work was in progress, that Dr. Krause alludes in the above passage.

It is curious to observe how, when a new idea gains the predominance in any department of science, the opinions of men oscillate for a time, usually swinging, like a pendulum, to a greater distance in the new direction in proportion as they have previously been pulled in the other. Thus for many years, as we all know, the idea of the transmutation of animals and plants, by any means whatever, was regarded as most unorthodox, and scarcely a naturalist could be found who would admit that such a thing was possible. Nowadays, since Mr. Darwin's well-known works have shown that such a thing is not only possible, but that in all probability it has taken place, and in fact that on no other assumption can we account scientifically for the facts observed in nature, we find nearly all transformists pinning their faith exclusively to the theory of 'Natural Selection,' and indeed, to a very great extent, especially in Germany, to that extreme form of the doctrine of which Professor Häckel is the prophet. Under these circumstances, it is well that, from time to time, naturalists should be reminded that there are matters upon which the theory of Natural Selection, admirably worked out as it is, leaves us in the dark; that there is room for some diversity of opinion as to the extent to which the innate qualities of the organism may govern its evolution; and that we have not yet arrived at the point at which a new systematic philosophy of the universe may be proclaimed as the only truth.

In his present work (which, after the fashion of musical composers, he somewhat affectedly characterizes as 'Op. 4.') Mr. Samuel Butler takes up the writings of Buffon, Erasmus Darwin, and Lamarck, and subjects them to a searching investigation, with the purpose of showing that the fundamental idea of the origin of species advocated by these writers is identical. This, we think, he does fairly enough, except in the case of Buffon, whose statements, even upon Mr. Butler's own showing, vacillate in a most remarkable manner. Our author endeavours to account for this by ascribing to Buffon an 'ironical' intention in many of the expressions used by him in discussing questions bearing upon the origin of organic forms by descent with modification,—that is to say, that Buffon, having, by some of the statements made in his earlier volumes, 'got across,' to use a vulgar phrase, with the ecclesiastical authorities, afterwards took the precaution of hinting what he really thought, or stating it as a possible result of a certain way of thinking,

* *Evolution, Old and New; or the Theories of Buffon, Dr. Erasmus Darwin, and Lamarck, as compared with that of Mr. Charles Darwin.* By Samuel Butler. Small 8vo. London: Hardwicke and Bogue. 1879.

and then shirking the difficulty which was staring him in the face by winding up his remarks after an orthodox fashion. From what we know of Buffon's writings, we are more inclined to think that he really never arrived at any clear result in his own mind upon the subject of the possible genetic relationships of species of animals, and that what he says on the subject in the passages referred to, is in each case the expression of the passing opinion entertained by him at the moment. If this is the case, he can hardly claim to be the founder of the doctrine of evolution, although it is quite possible that some of his remarks may have assisted Erasmus Darwin to arrive at his much juster and profounder views on the subject. That Darwin was the evolutionary parent of Lamarck, seems almost certain. Mr. Butler here does full justice to the merits of both these great naturalists. We may remark that his analyses of their opinions are preceded by sketches of their lives, which will be read with interest; but we must warn the reader that, in the case of Darwin, the biographical information is mainly derived from Miss Seward's work, which has been shown not to be particularly trustworthy.

Mr. Butler points out clearly that the great difference between the old and new schemes of evolution consists in the assumption, in the former, that the variations of the organism are brought about by a sense of need on its part, no doubt in consequence of changes in its surroundings, but into his further considerations on the nature of this governing impulse, we shall not follow him. We may, however, recommend Mr. Butler's little volume to our readers, as one the perusal of which will open up to them some new views on the subject of Evolution.

THE LAST ARCTIC EXPEDITION.*

WE are glad to be able to announce that Captain Markham's little narrative of his experiences of Arctic exploration when on board the *Alert*, in the late expedition under Captain Nares, has reached a fourth edition. He gives an excellent, popularly written, and lively account of the expedition, and although the description of its scientific results makes no part of his design, he could not avoid, even if he tried to do so, giving many details of matters of scientific interest. At this festive season, when most of us have to exercise our ingenuity in selecting suitable presents for the youngsters, we have particular satisfaction in calling our readers' attention to Captain Markham's pleasant and nicely illustrated little book.

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* *The Great Frozen Sea; a Personal Narrative of the Voyage of the Alert during the Arctic Expedition of* 1875–6. By Captain Albert Hastings Markham, R.N. Fourth edition. Sm. 8vo. London: C. Kegan Paul and Co. 1880.

BRITISH PLANTS.*

WE learn from the Preface to this little volume that the illustrated edition of Mr. Bentham's *Handbook of the British Flora* has been exhausted, and we presume that, probably for good reasons, the publishers have no present intention of bringing out a new one. Under these circumstances they have decided upon printing separately the beautiful and characteristic series of small woodcuts of British Flowering plants and Ferns, drawn by those excellent botanical artists, MM. Fitch and Worthington Smith, and issuing them in a small volume at a low price. New figures of the species admitted into the British Flora since the publication of the illustrated *Handbook* have been added, and the little book may thus be used as illustrative of the later editions of Mr. Bentham's, or of any other Flora. To facilitate reference in the latter case, the index, which follows the nomenclature of the original work, includes a good many synonyms indicated by Italic type. The figures themselves are too well known to need any words of commendation from us.

PHYSICS.†

THIS is a very convenient and useful little book, which may be of service both to pupil and teacher. Its object is simply described in the preface: 'If schoolboys' notes could be taken down satisfactorily, and always found when wanted, there would be little need of this book. It is intended to form the basis of a course of lessons, illustrated by experiments according to the requirements of the class and the resources of the teacher, and it may be supposed to represent the notes—somewhat expanded—which the teacher would desire the class to take down and learn.' The Notes are contained in rather more than a hundred pages, and comprise plain statements with simple formulæ upon Sound, Light, Heat, Magnetism, and Frictional and Voltaic Electricity. An Appendix of about fifty pages is devoted to examination papers, with references to the paragraphs in which the solution of each question occurs. The writer of this notice has found the little work extremely handy as a skeleton form from which to lecture, and still more as a basis on which to found a brief *resumé* of the preceding, with which it appears to him judicious to commence each subsequent lecture.

W. H. STONE.

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* *Illustrations of the British Flora; a series of wood-engravings, with dissections, of British Plants.* Drawn by W. H. Fitch and W. G. Smith. Sm. 8vo. London: L. Reeve and Co. 1880.

† *Lecture Notes on Physics.* By Charles Bird, B.A., F.R.A.S., Second Master in the Bradford Grammar School. London: Simpkin, Marshall & Co. Small 8vo, pp. 178.

UNITS AND PHYSICAL CONSTANTS.*

THIS book,' says the compiler in his preface, 'is substantially a new edition of my *Illustrations of the C. G. S. System of Units*, published in 1875 by the Physical Society of London, supplemented by an extensive collection of physical data. The title has been changed with the view of rendering it more generally intelligible. Though the publication is no longer officially connected with the Physical Society, the present enlarged edition is issued with the Society's full consent and approval.' In the first issue it was stated that its main object was to facilitate the *quantitative* study of Physics, and especially of the relations between its different branches. One uniform scale, a luxury hitherto unknown to the scientific calculator, is thus for the first time presented to the observer. The work is divided into eleven chapters, the first two of which deal with the general theory of Units, and the choice of three representing Mass, Length, and Time respectively. These are then applied to Mechanics, to Hydrostatics, to Strain, Stress, and Resilience, a new term introduced to remedy the ambiguity of 'Elasticity,' to Astronomy, to the velocity of Sound and of Light, to Heat, Magnetism, and Electricity. An appendix contains the Reports of the Royal Association Committee on Dynamical and Electrical Units, of which Professor Everitt was reporter.

The question of uniformity and the particular fitness for the purpose of the units chosen are too large for discussion in a mere notice of the book; but, granting its premises, there can be no doubt that the work has been thoroughly and judiciously carried out. W. H. STONE.

MODERN CHROMATICS.†

THE author of this very interesting work states his object to be to present, in a clear, logical, and, if possible, attractive form, the fundamental facts connected with our perception of colour, so far as they are at present known, or as they concern the general and artistic reader. For the explanation of these facts, the theory of Thomas Young, as modified and set forth by Helmholtz and Maxwell, has been consistently adhered to. It has also been his endeavour to present in a simple and comprehensible manner the underlying facts upon which the artistic use of colour necessarily depends. The book commences with a general statement as to the Transmission and Reflection of Light, in which it is shown that as painted or stained glass transmits enormously more light than pigments reflect in a properly lighted room, it follows that the worker on glass has at his disposal a much more extensive

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* *Units and Physical Constants.* By J. D. Everitt, F.R.S., &c., Professor of Natural Philosophy in Queen's College, Belfast. London: Macmillan. Crown 8vo, pp. 175.

† *Modern Chromatics, with Applications to Arts and Industry.* By Ogden N. Rood, Professor of Physics in Columbia College. 8vo. pp. 330, with 130 Illustrations. London: C. Kegan Paul & Co. (International Scientific Series.)

scale of light and shade than the painter in oils or water-colours. In speaking, next of colour-production by dispersion, the use of the prism is explained, and the infinite number of gradations into which white light can thus be broken up; the positions of the coloured spaces, and the proportion occupied by each, is estimated according to original observations,—blue and blue-violet representing 311; violet, 194; red, 149; green, and yellow, and yellowish-green, 104; green and blue-green, 103; and all the others far smaller areas, raising the total to 1000 parts. The irrationality of the prismatic spectrum is contrasted with the normal length as obtained by means of a diffraction-grating, red here standing for 330 parts, violet-blue for 117, orange-red for 104, blue for 74, and the rest for the same complement; yellow here occupying the centre of the spectrum, the red and orange being considerably increased to the detriment of the blue and violet. It seems that the eye is far more sensitive to changes of wave-length in the middle regions than at either extremity. This is considered to negative theories of colour founded on supposed analogies with music.

The Constants of Colour are next adverted to, and the mode of mixing white light with the colours of the spectrum described. Most coloured surfaces are shown to be more or less adulterated with white light, and in many instances the latter even preponderates. The first Constant is therefore *purity*, or absence of white. The second is a photometric problem, namely, relative brightness, or *luminosity*. Here an ingenious system of rotating discs is brought into play, in which mixtures of colour in the form of sectors are estimated against proportional combinations of simple black and white. Black can hardly be looked on as an absolute negation, since it reflects from two to six per cent. Allowing for this, if white paper be represented by a luminosity of 100, chrome yellow has one of 80·3, emerald green of 48·6, cobalt blue of 35·4, vermilion of 25·7, and ultramarine of 7·6. The *hue* of colour is the third and last Constant; this depending on wave-length and position in the normal spectrum. The production of Colour by Interference and Polarization occupies the fourth chapter, the latter never being seen out of the laboratory, while the former furnishes the brilliant plumage of the peacock, the humming-bird, and the *iridescent armour* of beetles. The colours of *opalescent media* are next studied, as seen in milky solutions, in smoke, and, on the grandest scale, in the sky.

Fluorescence and Phosphorescence are next discussed, and the more essentially artistic topic of Colour by Absorption is reached. To this process the colours of ordinary objects are almost entirely due. This is studied by the spectroscope in tinted glass, and diagrams are given, showing the very complex nature of the waves transmitted by red, orange, green, and blue specimens. A hand-spectroscope suffices to demonstrate the same law in blue paper, which, besides white light, giving a continuous spectrum, reflects red, yellow, blue, and violet. The white reflected does not, in a strong colour, exceed that just named as e nanating even from black. In velvet, an attempt is made to suppress all surface light, and to display only that which has penetrated deeply and thus become highly coloured. The green of vegetation offers a peculiar case. Extreme red is present, with orange, yellow, and yellowish-green, running into a full green. A mixture of red and green is, later on, shown to furnish yellow light.

A chapter on Colour-blindness is rather alien to the present notice. Helmholtz and Young's colour theory is reached in the eleventh chapter, and Maxwell's colour discs are explained. Overlapping spectra in Helmholtz's hands proved the singular fact that union of pure blue with pure yellow light, produces, not green, but white, thus overthrowing the hypothesis of Brewster. A section follows on the Mixture of Colours, founded mainly on Maxwell's Rotating Colour-discs and Dove's Dichroscope, the results of which are compared with mixtures on the artist's palette. Binocular Vision is afterwards called in aid, and many valuable practical results are recorded. The book, indeed, from this point, becomes less physical, but none the less useful, from the predominance of æsthetic detail. It would be impossible in limited space to analyze minutely the last chapters; but their general scope may be gathered from their successive headings:—Systems of Colours; Contrast; Combinations in Pairs and Triads; and the Use of Colour in Painting and Decoration.

It will be easily seen from what has been hastily sketched above, that this book is of exceptional value and originality; chiefly because it succeeds in blending harmoniously the latest researches in Physical Optics with the rules and dicta which are the hereditary property and the traditional foundation of Pictorial and Decorative Art.

W. H. Stone.

SCIENTIFIC SUMMARY.

ASTRONOMY.

Mars.—At the November meeting of the Royal Astronomical Society, Professor J. C. Adams read an interesting paper on the motion of the nodes of the satellites of Mars, and the important information which the observations of this motion would throw on the figure and constitution of the planet. Assuming that the planet was a symmetrical spherical body, Mr. Marth had shown, in the *Astronomischen Nachrichten*, No. 2280, that the nodes of the orbits of the satellites would have an annual motion, due to the Sun's action, amounting to 0°·06 in the case of *Phobos*, the inner satellite, and to 0°·24 in the case of *Deimos*, the outer satellite. If, then, the satellites of *Mars* preserved a constant inclination to the orbit of *Mars*, as would be the case were the planet a symmetrical spherical body, from the difference in the rate of motion of their nodes, they would in course of time have their orbits very much inclined to one another. So much so, that though at present the two satellites move in nearly the same plane, the plane coinciding with the plane of the equator of *Mars*, yet a thousand years hence they would move in orbits whose planes were inclined to each other by an angle of nearly 49°. Professor Adams draws attention to the fact that, if the planet *Mars* be not spherical but spheroidal, like our Earth, the effect of this deviation from a sphere would be to tend to make the satellites move in orbits very nearly coincident with the plane of the equator of *Mars*, and in this case the planes of the orbits of the satellite would always be nearly coincident, as they are known to be at present. As Laplace has shown, if the motion of the node due to the effect of the ellipticity of the planet be much greater than that due to the action of the Sun, the orbit of the satellites will always nearly coincide with the plane of the equator of the planet. Professor Adams now shows that, even if the planet be supposed to be only very slightly spheroidal, the effect of the ellipticity will very much exceed that of the Sun, so that the satellites will always move in orbits but slightly inclined to the plane of the equator of the planet. Now the effect of the ellipticity of the planet cannot be well determined from the motion of the node, because, owing to the slight inclination of the orbits, it will be difficult to accurately determine the motion of the nodes from observation. But the orbits of both satellites seem to be sensibly eccentric, and it will not be difficult to determine from

observation the motion of the apse or point where the satellite approaches closest to the planet; and from this motion it will be possible to accurately determine the ellipticity of the planet, and in this manner from the observed inclination of the orbit of the satellite, ascertain with accuracy the position of the equator of *Mars* and the figure of the planet. It is unnecessary to point out the great interest attaching to the exact determination of the position of the equator, and consequently of the poles, of *Mars*. There is some reason to believe from observation that the white polar caps of the planet, which are generally held to be due to the presence of arctic ice and snow, are not concentrically situated round the poles of the planet. It would throw material light on the physical constitution of the planet if this point were definitely settled.

The Secular Acceleration of the Mean Motion of the Moon.—The gradual quickening of the motion of the Moon in its revolution around the Earth has long been one of the most interesting points in the theory of the solar system. The comparison of the places assigned to the Moon by theory and observation seems to show that the observed acceleration is much greater than that assigned by theory. In consequence it has been supposed that a portion of the apparent acceleration may be really due to a slow retardation of the rotation of the Earth from the friction of the tides of the ocean against the crust of the Earth. Lately the researches of Professor Newcomb on the early observations of the Moon would seem to show that when the tables of the Moon are properly corrected, there is far less discordance between the observed and theoretical values of the acceleration of the Moon's motion than has hitherto been supposed. Lately Mr. J. N. Stockwell, in the *American Journal of Science*, November, 1879, has drawn attention to a new origin of a secular acceleration in the mean motion of the Moon. It has long been known that the attraction of a spheroidal body like the Earth on a distant body like the Moon is slightly different from that of a sphere of the same mass, the attraction being greatest when the satellite is in the plane of the equator and smallest when in the plane passing through the poles. For this reason a satellite revolving around the Earth in an orbit inclined to the equator would move slower than if it were moving in an orbit which was not inclined to the equator. It is known that at present the inclination of the lunar orbit to the terrestrial equator is very slowly decreasing, and it follows, therefore, that the Moon is gradually quickening in its motion round the Earth. Hitherto, however, it has been supposed that this acceleration was so small that it could not attain, even in the course of many centuries, to an amount which could be detected by observation. According to Mr. Stockwell, this is not so, as from his calculation he makes the acceleration from this cause amount to 0″·1981 per century. The amount of the acceleration varies as the square of the number of centuries, so that if this calculation be correct, it will be necessary to alter, by nearly five minutes, the theoretical time of the occurrence of the famous early eclipses of the Moon observed in Babylonia, and quoted by Ptolemy in his *Almagest*.

A New Planetary Nebula.—On November 14, 1879, while the Rev. T. W. Webb, F.R.A.S., the well-known astronomer, was sweeping the heavens near the constellation *Cygnus*, with his 9¼-inch reflector and a low-power eye-piece, he noticed an object resembling a 9th magnitude star, which

seemed to differ in appearance from similar stars. This led him to examine it with higher powers, when this object was seen to be not really a star, but to show an ill-defined bright disc, about 4″ in diameter, and of a bluish colour. When closely examined it seemed to be surrounded by a faintish glow. From Mr. Webb's description this object must have appeared similar to the planet *Uranus* when seen through a white, hazy mist. On referring to the star catalogue it was found to be the object observed as a star by Argeländer during his survey of the Northern Heavens, and recorded by him as No. 4004 Zone + 41°. Its place for the year 1880 is R.A. $21^h\ 2^m{\cdot}5$ Decl. + 41° 45′·3. Mr. Webb communicated an account of his observation to Dr. Copeland at Lord Lindsay's observatory at Dun Echt, in Aberdeenshire, who took the first opportunity of observing this object with the fine 15-inch refractor belonging to the observatory. According to Dr. Copeland this object is not quite circular, and has a sharp nucleus near its north preceding edge, and a faint diffusion of light on its opposite direction. It is, therefore, an exceptionally compact and bright planetary nebula. When examined with the spectroscope it gives three bright lines, one far brighter than the others, and these bright lines agree well in position with those found by D'Arrest to be generally given by nebulæ of this description.

Solar Parallax from Meridian Observations of Mars.—In the 'Observatory,' for November, 1879, Mr. A. M. W. Downing, of the Royal Observatory, Greenwich, has calculated the value of the solar parallax which results from the meridian observations of *Mars* made in the summer of 1877 at the observatories at Leyden and at Melbourne. Comparisons were only made on days when *Mars* and the comparison stars were observed at Melbourne, either on the same day as at Leyden, or on the following day. Twenty-nine corresponding sets of observations were obtained, and from them the solar parallax was computed. The separate results range between 8″·65 and 9″·39, and when properly combined, give as the final result:—

$$\text{Mean solar parallax} = 8''{\cdot}960 \pm 0''{\cdot}051.$$

Mr. Downing remarks, 'In the light of recent researches on the subject, we must, I suppose, consider this value of the solar parallax to be too large; it is, however, to be remarked that Professor Winnecke obtained the value 8″·96, and Mr. Stone that of 8″·94, from meridian observations of *Mars* in 1862; and though Professor Newcomb's discussion gave the result 8″·855, still, as Mr. Stone has pointed out, the smaller value depends chiefly on the use of the Santiago observations, which he declares to be inadmissible. It appears, therefore, that from meridian observations of *Mars* we get a parallax of not less than 8″·9; and we are almost forced to the conclusion that there is something in the *method*, which persistently tends to give a large result; if this be so it introduces another very perplexing element into researches on solar parallax.'

On examining the separate results given by Mr. Downing, it would appear that there is some trace of systematic error in the observations or in their reduction. Thus, as the result of the fourteen separate determinations deduced from observations made before opposition, we have a solar parallax of approximately 9″·037, whilst as the result of the fifteen separate determinations deduced from observations made after opposition, we have a solar parallax of

only 8″·917. This difference of 0″·120 is too large. The chief objection to this process is great liability to systematic error, not only from personality, but unless great care be taken, from errors in the correction for refraction, as well as in the assumed variation of the tabular error in declination. In the absence of any details it is impossible to say how far the result obtained by Mr. Downing may be affected by systematic errors of this nature.

The November Meteors.—In this year, as in the preceding years, the number of meteors belonging to the great system of *Leonids*, which have been observed, have been very few. The meteor-shower of November 12–14, is now reduced to the merest phantom of the great showers of the year 1866 and immediately succeeding years. At the Royal Observatory, Greenwich, the observation lasted for about four hours on each of the nights November 12, 13, 14, the circumstances being very favourable, the night being clear and there being no moon. The number of meteors seen were only 13, 19, and 32, on each night respectively, and of these only 6, 9, and 18, respectively belonged to the great system radiating from the constellation *Leo*. On November 12 and 13 watch was also kept by Mr. Corder, at Writtle, near Chelmsford; but only a very few *Leonids* were observed. Mr. W. F. Denning, of Bristol, also kept a close watch, with a similar result. On the 13th he observed a short, but very decided outburst of fine *Leonids;* but it soon died away. This short shower consisted of eighteen fine meteors, swift, but some leaving vivid bright trains. At Bedford Mr. T. P. Gray kept watch with a very similar result. We shall have to wait probably for years for another great display of these meteors.

Jupiter.—During the past summer great interest has been manifested in observation of the planet *Jupiter*, mainly on account of the presence on the southern bright zone of a long, narrow, elliptical spot, of a dark reddish colour. This spot seems to have first attracted general notice in the early part of the summer of 1879, though there is some reason to believe that it was visible as a very faint object in the preceding year. During the early part of the year the spot seems to have been lighter in colour than the great equatorial belt, which was brownish-red in hue. According to the measures of Messrs. Gledhill and Neisten, the spot was in south latitude 20° (Jovian), and in length covered about 33° of Jovian longitude. Its breadth was about 6° of Jovian latitude. Later on both the red spot and the great equatorial belt appreciably deepened in tint, and the elliptical spot is generally described by observers as being of the same hue as the equatorial belt, only more intense. During November it appeared to have slightly decreased in size, and to have moved a little nearer the equator. M. Neisten, of the Royal Observatory of Brussels, who has carefully watched the spot since June 25, 1879, is of opinion that it is surrounded by a bright elliptical ring, a ring brilliant white in hue, and much whiter than the bright zone on which the spot is situated. Other observers have seen a similar appearance. Mr. John Brett is of opinion that this bright ring is probably merely due to the effect of contrast. The Rev. T. W. Webb has noticed of late a haziness in the appearance of this spot, and describes it as only a little redder than the cinnamon-coloured equatorial belt. He describes the spot as having somewhat the appearance of two tufts of reddish wool touching each other. From comparisons which have been made, the conclusion has been drawn that this

peculiar red spot is slowly moving around *Jupiter*—an interesting point which ought to be carefully investigated.

Another feature, which has been very striking during the last opposition of *Jupiter*, is the common occurrence of round or oval, bright white spots. So bright and circular have these objects been that they could easily be taken for satellites in transit. These spots have been long known to occur. Some time back Mr. Brett pointed out that they were bordered on one side by shades, as if they actually cast shadows. Of late, however, it has been noticed that these shadings occur on both sides of the spots, and even all round, throwing them up, as it were, into relief. Under these circumstances, it is evident that these dusky borders cannot be shadows cast by the white spots, as supposed by Mr. Brett. Mr. Corder has concluded from his observations that these white spots are moving much quicker than the great red spot, as he is of opinion that he has been able to see one of these spots gain half a revolution of the planet on the red spot during a period of only twenty days.

Satellites of Mars.—The outer satellite of *Mars*, *Deimos*, was observed by Mr. A. Common, of Ealing, with his fine 37-inch reflector, on September 21st, 1879, more than three weeks before it was anticipated it could be seen with even the great Washington Equatorial. Later Mr. Common succeeded in observing the inner satellite, *Phobos;* and since then the two satellites of *Mars* have been regularly observed and measured at the Ealing Observatory. At Washington the outer satellite, *Deimos*, was seen on October 10th, the very day it was anticipated that it would come within reach of the great 26-inch equatorial. Since October 12 both satellites have been regularly observed by Professor Asaph Hall, at Washington. A measure of the position of *Deimos* was also obtained by Mr. Maunder, with the $12\frac{3}{4}$-inch equatorial of the Royal Observatory at Greenwich. Several observations have also been obtained at the Paris Observatory. At Dun Echt Observatory, Aberdeen, Lord Lindsay saw the first satellite with the 15-inch equatorial, but clouds prevented its being measured. Mr. Common is of opinion that any one who can see *Enceladus*, the second satellite of *Saturn*, ought to be able to see with ease both satellites of *Mars*, if only the precaution be taken to hide the planet behind a bar. He is of opinion that the outer satellite, *Deimos*, is quite as bright as *Enceladus*. *Phobos*, though harder to see from its proximity to the planet, is known to be far brighter than *Deimos*, probably as bright as *Tethys*.

By comparing the observations of the two satellites with the ephemeris founded on the observations made during 1877, Professor Asaph Hall finds that *Phobos* comes to its elongation $44^{m}{\cdot}0$ before the predicted times, the error in areocentric longitude of his ephemeris being $+ 34^{\circ}{\cdot}3$, so that the periodic time ought to be reduced by $1^{s}{\cdot}074$, and would be $7^{h}\ 39^{m}\ 13^{s}{\cdot}966$. In the case of *Deimos*, the outer satellite, the error of the ephemeris is very small. This correction will bring the value of the mass of *Mars* derived from the inner satellite into better agreement with the mass of *Mars* as determined from the motion of the outer satellite.

CHEMISTRY.

On the New Element, Scandium.—Clève has studied the properties of the new earth, Scandia, discovered by him a few weeks after Nilson's announcement, to which we drew attention (*Pop. Sc. Rev.*, Oct. 1879, 424), in gadolinite and yttrotitanite. The former mineral contains 0·002 to 0·003, and the latter 0·005 per cent of scandium. Scandia has the formula $Sc_2 O_3$, the ammonium- and potassium-scandium sulphates, as well as the oxalates and selenites, establishing this point. From some eight to ten grammes of scandia by repeated decomposition of its nitrate, one gramme of a white earth was obtained. This was converted into a sulphate and calcined, when 1·451 gramme gave 0·5293 gramme of scandia, which yields the number 44·91 as that of the atomic weight of scandium. If scandia be taken to be Sc O, the result given above would point to 45·94 as the molecular weight of the newly-found element, differing materially from 105·83, the minimum value, as found by Nilson. Careful examination with the spectroscope, by Thalén, proved Clève's scandia to be pure; it is inferred, therefore, that in the 0·3298 gramme of 'Scandia,' on which Nilson worked, there must have been only 0·043 gramme of the new oxide and seven or eight times as much ytterbia. Clève chooses 45 as representing most closely the atomic weight of scandium. Scandia, $Sc_2 O_3$, is a perfectly white, light powder, infusible, and resembling magnesia. Acids, even the strongest, attack the oxide only with difficulty; it is, however, more readily soluble than alumina. Its density is 3·8. The hydrate, like that of alumina, is white and bulky. It does not absorb carbonic acid from the air, is insoluble in an excess of ammonia or potash hydrate, and does not decompose ammonium chloride. Its salts are colourless, with an acrid, astringent taste, quite different from the other salts of the metals of the yttrium group. The sulphate does not crystallize distinctly; the nitrate, oxalate, and acetate and formiate, on the other hand, form crystals. The chloride gives no spectrum when heated in a gas flame. Its solution is precipitated by ammoniac and potassic hydrate, and the precipitate is not soluble in an excess of either reagent. Tartaric acid prevents the precipitation by ammoniac hydrate in the cold. Sodium carbonate gives a precipitate soluble in excess of the reagent. Sulphuretted hydrogen gives no precipitate; ammonium sulphide throws down the hydrate; sodium phosphate gives a gelatinous precipitate; oxalic acid gives a curdy precipitate which soon becomes crystalline. Sodium hyposulphite and sodium acetate at once cause precipitates in boiling solutions; the precipitation, however, is incomplete. The discovery of scandium is of peculiar interest, from the fact that its existence and properties were predicted by Mendelejeff, as a consequence of his law of periodicity, and called by him *Ekabor*. The remarkably close correspondence between the properties of ekabor and those of scandium is shown in Clève's paper, by printing them in parallel columns. (*Compt. Rend.*, 1879, lxxxix. 419.)

On Two New Elements, Thulium and Holmium.—Since the ytterbium of Marignac and the scandium of Nilson, both of which were discovered in erbia, give colourless salts, Clève endeavours to distinguish the substance in this earth which gives the red colour and the beautiful absorption spectrum

to its salts, in order to ascertain if it was erbium itself. Employing the residues from which Nilson had separated ytterbia and scandia, he found it impossible to obtain a red oxide with a constant molecular weight, even after several hundred decompositions. Suspecting the presence of the unknown oxide he induced Thalèn to examine the spectrum of what he regarded as the purest erbia, and to compare it with that of yttria and ytterbia. Certain absorption bands in the last fractions suggested that the colour of erbia is due to the presence of three oxides giving absorption spectra. The reddest of the fractions (RO molecular weight = 125–127) were united and submitted to a long series of decompositions, one fraction being treated for ytterbia, another for yttria, and a third, intermediate, containing the concentrated erbia. At the same time, he attempted to concentrate the colouring matter in residues A, rich in ytterbia, and B in yttria. After pushing the treatment as far as possible with the amount of material at his disposal, he handed over the five fractions to Thalèn, who found bands common to all the fractions, and due probably to erbia. The following bands varied markedly from one fraction to another:—

		Fraction A.		*Erbium?*	*Fraction B.*	
Wave length.		Extr. from ytterbia residue.	Extr. from Erbia, 126–127.	Mean fractions, 126–127.	Extr. from Erbia, 126–127.	Extr. from residues rich in yttrium.
x	6480	strong	quite strong	fails	fails	fails
y	6400–6425	fails or trace	trace	weak	weak	pretty strong
z	5360	fails	fails or trace	trace	feeble	quite strong

Hence *x* belongs to fractions situated near ytterbia, and does not exist in fractions from yttrium. But, on the other hand, *y* and *z* fail in the ytterbium residues, but grow more distinct as yttrium is approached. The ytterbia fractions gave a rose-colour with a tinge of violet; the yttria fractions had an orange tint. For the element coming between ytterbia and erbia, characterized by band *x* in the red of the spectrum, Clève proposes the name of *Thulium*, from Thule, the ancient name of Scandinavia. The atomic weight, Tm, should be about 113 if its oxide be RO. Erbium proper, which has the common bands mentioned, has the atomic weight 110–111. Its oxide is of a light rose colour. The third metal, characterized by the *y* and *z* bands, and which is between erbia and terbia, should have an atomic weight below 108. Its oxide appears to be yellow. For it the name of *Holmium* is proposed, derived from the Latin name of Stockholm, the environs of which are rich in yttria minerals.—(*Compt. Rend.* 1879, lxxxix. 478.)

Notes on the two new Elements announced by Clève.—Soret points out that he showed in the spring of 1878 that the two bands which characterize holmium do not belong to erbia, but to a new earth which he called provisionally X, and which is perhaps identical with philippium, since discovered by Delafontaine. Besides these two bands, Soret recognized three other absorption bands; one less refrangible than A, a second overlapping the band of erbia in the indigo, and a third (faint) in the violet a little beyond *h*. In the ultra violet spectrum six absorption maxima exist between H and R. In samarskite the earth X is relatively to erbia much more abundant than in gadolinite. As to the red ray which characterizes thulium, Soret had already observed that also in some ytterbia products which had been

sent to him for examination by Marignac. Lecoq de Boisbaudran confirms Soret's statement in regard to the red thulium ray, having observed it in a sample of impure yttria which he had received from the latter some months ago. He inclined to the belief that all the bands were caused by erbia, modified by the conditions. But special experiments led him to agree with Soret, and to accept the possibility that erbia was a mixture of three oxides.—(*Compt. Rend.* 1879, lxxxix. September.)

Oxidation of Formic and Oxalic Acid by Ammonium-copper oxide.—The oxidating action of this substance on azotized bodies has already been pointed out by Löw. Cazeneave now finds that it has a similar action on formic and oxalic acid. At ordinary temperatures and at 100° no change occurs, if the substances be heated together in closed tubes; at 150°, however, both acids are rapidly oxidized to carbonic acid:—

$$CH_2O_2 + 2\,CuH_2O_2 + 2\,NH_3 = CO_3H_2(NH_3)_2 + Cu_2O + 2\,H_2O.$$
$$C_2H_2O_4 + 2\,CuH_2O_2 + 4\,NH_3 = 2\,CO_3H_2(NH_3)_2 + Cu_2O + H_2O.$$

If the solutions be subsequently exposed to the air, oxygen is taken up and ammonium-copper carbonate is formed.

$$CO_3H_2(NH_3)_2 + Cu_2O + O = CO_3Cu(NH_3)_2 + CuH_2O_2.$$

When the formic and oxalic acid are in large excess, the copper oxide is reduced to copper.—(*Bull. Par.* 1879, xxxii. 277.)

The Presence of Alcohol in Animal Tissues.—To clear up some points hanging on the investigations of Schrader and Dusch, the following experiments were tried by J. Bechamp (*Compt. Rend.* 1879, lxxxix, 573). A piece of horseflesh, weighing three kilog., was dipped in boiling water for ten minutes, and placed in a dish on the 8th June, and closely covered up with a thick linen cloth. On the 16th July the flesh had become very foul and full of life, but the air does not appear to have penetrated to the centre. Alcohol amounting to 0·8 gramme was obtained, a part of which was burnt, the rest oxidized with chromic acid to aldehyde, and then to acetic acid, the soda salt of which was prepared and identified. In addition to this, about ten grammes of sodium acetate, butyrate, and salts of other higher acids, were obtained. Another mass of horseflesh, weighing four kilog., was simply left to itself for four days, and on subsequent treatment yielded alcohol as before, but in less quantity, as well as acetic and butyric acid. The next question which suggested itself to the author was to determine whether alcohol forms a constituent of a living organ. It has been shown by A. Béchamp that alcohol is a normal constituent of urine and milk; the question hence arises whether it also occurs in the tissues. Fresh sheep's liver, immediately after the animal was killed, contained alcohol; fresh and still warm sheep's brains also contained it, and in larger quantity than the liver; fresh and still warm bullock's brains also contained it. These results show that the presence of alcohol in the tissues does not necessarily indicate poisoning.

GEOLOGY AND PALÆONTOLOGY.

Formation of Mountains.—M. de Lapparent has an excellent article on this subject in the *Revue des Questions Scientifiques* for July last. He points out that the changes of position, the elevation, and especially the folding, of strata observed in mountainous districts are due to energetic lateral compression. Elie de Beaumont taught that mountain-chains do not occupy the centres of continents and show symmetrical slopes on both sides, but that they are to be found near the sea, and have a precipitous slope on the side facing the sea, whilst the opposite side slopes gently away, forming the mass of the continent, and usually terminates in the opposite ocean by a line of low country. This view has been formulated as a law by several geologists, especially in America, where the long line of the Rocky Mountains and the Andes furnish such a striking example in its support; and Professor Dana has added the following rider to it, that when two chains of elevations form the two shores of a continent, the one facing the largest ocean is the higher one. M. de Lapparent indicates that in order to apply these principles to the Old World mountains, and especially to those of Europe, it is necessary to force the facts a little, and hence he is led to the belief that while it is perfectly true that chains of mountains are always formed in the vicinity of the ocean, it is necessary, in order to understand their distribution, to consider the geographical conditions that prevailed at the period of their formation. He sums up his views in the following formula:—'At the epoch when a chain of elevations has just attained its principal relief, it consists of two slopes of very unequal inclination, one of which, gently inclined, is connected with the continent, while the other, which is abrupt, directly faces the sea.' Thus the Pyrenees, which are shown by geological evidence to have been elevated after the formation of the Nummulitic and before that of the Miocene deposits, were united by a gradual slope towards the south with the Spanish continent, while the foot of the precipitous northern face was washed by the Miocene sea. The Alps date from the interval between Miocene and Pliocene times. To the north they joined on by a gentle slope to the plains of northern Germany, while towards Lombardy they formed a vertical wall, at the foot of which were deposited the sediments of the Sub-apennine sea. M. de Lapparent refers to other European chains, and then formulates the following general law:—'A chain of mountains, at the moment of its formation, always occupies a littoral situation; it does not depart from this afterwards, except when the continent is enlarged by new additions obeying the same law. If, therefore, at the present day, the Scandinavian mountains on the one hand and the Cordillera of the Andes on the other, emerge directly from the depths of the ocean, this is because these two chains belong to the most recent formations which have been produced on the globe; and geology, as is well known, fully justifies this conclusion.'

From the consideration of the soundings which have been so rapidly accumulated of late years, M. de Lapparent arrives at the conclusion that the great depths of the sea, as a general rule, are the counterparts of the great elevations of the land, and lie directly at their base, and hence he concludes that 'at the moment when the profile of one of the lines of relief of the

earth's surface becomes strongly marked, this profile includes an abrupt central line, joining at its extremities with two gently-inclined lines; of the two angles thus formed that which has its apex outward constitutes the crest of a mountain-relief, while the other forms the ridge of a marine depression. In this way, at the moment when a great shore-line is constituted, it is marked on the one hand by a projecting chain, the origin of a continent, and on the other by a deep fosse, in which the sea collects; the projecting chain moreover may only emerge in part.' These correlated elevations and depressions are considered by M. de Lapparent to be due to foldings in the comparatively thin crust of the earth caused by the contraction of its fluid nucleus. M. de Lapparent's article contains many remarks of interest to geologists upon various matters more or less connected with, or explained by his view of the origin of mountains, and it will well repay careful perusal. He summarizes his results as follows: —'All the inequalities of the surface of the globe have a single cause, which is incessantly in action, although it must probably manifest itself only at intervals, namely, the contraction of the fluid nucleus in losing its heat, whence proceeds, for the solid envelope, the necessity of adapting itself continually to the new form imposed upon it by the conditions of its equilibrium. It is thus that, since the earliest ages of the globe, the continents have been formed by successive additions, which gradually rendered their contour more and more complicated. The surface of the sea has constantly diminished in extent, but at the same time its depth has constantly increased with the elevation of the continents. Hence have arisen those diverse physical conditions, in which the natural effects of latitude are complicated by a thousand modifications due to the nature of the soil, to altitude, to exposure, to vicinity to, or distance from, the sea. Thus all those external conditions, the variety of which gives so great a charm to our globe, at the same time that it is the most powerful of stimulants to human activity, are contained in their germ in the law that we have laid down.'

Chalk Flints.—At the last meeting of the Geological Society (December 19th), Dr. Wallich read a contribution towards the solution of that *quæstio vexata*, the origin and mode of formation of the flints which occur so abundantly in certain parts of the Cretaceous series. Taking as the basis of his conclusions the fact brought to notice by him in 1860, namely, that the whole of the Protozoan life at the sea-bed is strictly limited to the immediate surface-layer of the muddy deposits, he pointed out in detail the successive stages of the flint-formation, from the period when the chief portion of the silica of which they are composed was eliminated from the ocean-water by the deep-sea sponges, to the period when it became consolidated in layers or sheets conforming to the stratification of the Chalk. In relation to this subject the author claims to have sustained the following conclusions:— 1. That the silica of the flints is derived mainly from the sponge-beds and sponge-fields, which exist in immense profusion over the areas occupied by the Globigerine or calcareous 'ooze.' 2. That the deep-sea sponges, with their environment of protoplasmic matter, constitute by far the most important and essential factors in the production and stratification of the flints. 3. That whereas nearly the whole of the carbonate of lime, derived partly from Foraminifera and other organisms that have lived and died at the

bottom, and partly from such as have subsided to the bottom only after death, goes to build up the calcareous stratum; nearly the whole of the silica, whether derived from the deep-sea sponges or from surface Protozoa, goes to form the flints. 4. That the sponges are the only really important contributors to the flint-formation that live and die at the sea-bed. 5. That the flints are just as much an organic product as the Chalk itself. 6. That the stratification of the flint is the immediate result of all sessile Protozoan life being confined to the superficial layer of the muddy deposits. 7. That the substance which received the name of '*Bathybius*,' and was declared to be an independent living Moneron, is, in reality, sponge-protoplasm. 8. That no valid *lithological* distinction exists between the Chalk and the calcareous mud of the Atlantic; and *pro tanto*, therefore, the calcareous mud may be, and in all probability is, 'a continuation of *the* Chalk-formation.'

Bohemian Permian Amphibia.—A well-known Bohemian palæontologist, Dr. Anton Fritsch, has commenced the publication of a monograph on the fauna of the coal and limestone of Permian age, occurring in Bohemia. A most interesting assemblage of fossils has been discovered in these rocks within the last ten years. It includes, at present, about forty-three species of amphibians, thirty-three fishes, eleven arthropods, and an *Anthracosia*, and many of the forms are exceedingly remarkable. They are being described in detail and admirably figured by Dr. Fritsch, in the work *Fauna der Gaskohle und der Kalksteine der Permformation Böhmens*, the first part of which has quite recently appeared. In this the author gives an account of the geological formation from which the remains described have been obtained, and other general information connected with the fossils, and then describes the species of Amphibia, preceding his descriptions with some generalities upon the group to which they belong. He refers all the forms noticed in his first part to Cope's Order Stegocephali, which comprises the Labyrinthodontia, Ganocephala, and Microsauria of other writers, and places them under four genera, namely, *Branchiosaurus*, *Sparodus*, *Hylonomus*, and *Dawsonia*.

Branchiosaurus resembles the Earth-salamanders in possessing gills, and the author remarks that in their broad rounded head, short thick body, well developed limbs, terminating in digits, and their rudder-like tails, they suggest comparison with larval forms of the existing Urodela. *Branchiosaurus salamandroides* attained a length of two and a half inches; its skeleton was ossified early in life, the bones being completely defined in specimens only a quarter of this length. The skin was dense and its impression is preserved in most of the specimens; when highly magnified, ridges are seen upon it, constituting the first indications of scales, which become more developed on the lower surface of the body. The general form of the head is nearly semicircular; the maxillaries and premaxillaries carry numerous short pointed teeth; the orbits are rather large, and in well-preserved examples show a circle of about fourteen sclerotic bones; the lower jaw is attenuated in front, composed of three elements,—articular, angular, and dentary, the latter having about twenty teeth; and on each side of the hinder part of the skull there are two branchial arches, which bear two rows of small, spheroidal bones, each furnished with a curved spine. The trunk vertebræ are about twenty in number, and all except the first bear ribs. The sacrum consists of a single

vertebra, and beyond this come about twenty-one caudals, also bearing ribs. Four other species of *Branchiosaurus* are described.

Sparodus, of which two species (*S. validus* and *crassidens*) are noticed, is nearly allied to the genera *Hylerpeton* and *Batrachiderpeton*. The skull is more wedge-shaped than in *Branchiosaurus*: the vomer and the palatine bones bear numerous teeth. The genus *Hylonomus* is recognized from small portions of jaws, believed to indicate two species; and allied to this genus is a new one, which the author names *Dawsonia*, after the distinguished Canadian geologist and paleontologist who established the former genus.—*Geological Magazine*, November, 1879.

Concretions and Inclusions in Granite.—Mr. J. A. Phillips has communicated to the Geological Society (November 19, 1879) the results of his investigations of the discordant patches often met with in granites. These patches are sometimes angular, sometimes rounded, sometimes clearly defined, at others gradually melting away into the surrounding mass, but generally finer in texture than the latter. The chemical and microscopic examination of such patches in the granites of Cornwall, Shap Fell, Aberdeen, Peterhead, Fort William, and North-eastern Ireland, has led Mr. Phillips to distinguish two classes of these inclusions, namely:—1. Concretionary patches, the result of the abnormal aggregation of the minerals constituting the granite itself, generally containing more plagioclastic felspar, mica, or hornblende than the latter, and in all probability formed contemporaneously with the solidification of the mass; and 2. Included fragments of schistose or slaty rocks, often not very highly altered, caught up from the rock-masses through which the granite has forced its way. In the discussion which ensued upon the reading of Mr. Phillips' paper, Mr. G. W. Ormerod stated that the concretionary patches were to be seen on the eastern side of Dartmoor, where they are generally of an oval form and are called 'mares' eggs;' and Professor Ramsay remarked that fine examples of them are visible on the steps of the Duke of York's Column.

British Secondary Comatulæ.—Mr. P. Herbert Carpenter has described before the Geological Society (3rd December, 1879) seven new Comatulidæ from the Cretaceous and Oolitic series of Southern England, and given some new facts respecting *Glenotremites paradoxus* of Goldfuss from the Upper Chalk. This species is remarkable for the presence of certain characters which are very conspicuous in the recent *Antedon Eschrichtii*, and also in a new species dredged by the *Challenger* at Heard Island, in the South Atlantic, namely, the presence of strong ribs on the inner wall of the centrodorsal, five of which, interradial in position, are much more prominent than the rest. So far as is yet known, these features occur in no other recent Comatula, with the exception of one species from the South Pacific, in which there is a faint indication of such ribs; but they are all equal. Another Antedon species is described from the Chalk of Sussex. It differs from *Antedon paradoxus* in the absence of these ribs, and in the shallowness of the centrodorsal cavity.

Two species were described from the Gault of Folkestone. One is an Antedon, with no special relations to any recent forms. It might have lived as well at 20 as at 500 fathoms. But the other species is an Actinometra, possessing certain characters only known to occur in species from quite shallow water, 20 fathoms or less, in the Philippine Islands and Malay Archi-

pelago. The centrodorsal is a flat plate, nearly on a level with the surface of the radials, or sometimes even below them, separated from them by clefts at its sides, and entirely devoid, not only of cirrhi, but also of cirrhus-sockets. This condition is only an extreme stage of the metamorphosis of the centrodorsal piece, which bears cirrhi for a time after its liberation from the larval stem; but these cirrhi eventually disappear and their sockets become obliterated. The *Challenger* collection contains a series of specimens of *Act. Jukesii*, from Torres Straits, which illustrate this point very completely; and it is, therefore, of no small interest to find a fossil Comatula which shows one of the extreme stages of the metamorphosis.

The large size of the three Antedon species from the Chalk and Gault is very remarkable. *Ant. paradoxus* has a centrodorsal half as wide again as that of any recent form; while *Ant. Eschrichtii* is the only recent species with a centrodorsal approaching the size of those of the other Chalk Antedon, and of that from the Gault. *Act. Lovéni*, from the Gault, however, and the older Comatulæ, all had small calices like most recent species. An elegant centrodorsal (*Ant. rotundus*) is described from the Haldon Greensand, and also two species from the Bradford Clay. One is an Antedon, the oldest known, with no special characters; the other is an Actinometra, with a a centrodorsal essentially like those of species now living in shallow water in the Philippines and Malay Archipelago. The oldest known Comatula, an Actinometra from the Bath Oolite, has similar relations.

Argillornis longipennis.—Some two years ago Professor Owen described before the Geological Society the humerus of a large bird from the London Clay of Sheppey, for which he proposed the above name (see *Popular Science Review*, New Series, Vol. ii., p. 106). He was inclined from the first to regard this bone as belonging to the wing of a large aquatic bird; and the recent discovery of a portion of a bird's skull in the same deposit would seem to be confirmatory of Professor Owen's views. In this specimen, which was described by the Professor before the Geological Society, on the 5th November, the lower jaw and the fore-part of the upper jaw are deficient; and the characters presented by it, like those of the humerus previously described, were said to approximate the fossil most nearly to the Albatross among existing birds, although, like *Odontopteryx*, it differed from *Diomedea*, and also from the Cormorant and the Totipalmates generally, in the absence of the basirostral external nares and of the supraorbital gland-pits. The present fossil differs from *Odontopteryx* in having the fore-part of the frontal broader and the upper tract of the bill less defined, as also in some other characters; but no comparison of the palatal structure can be made upon the existing specimens. In point of size, taking the Albatross as a term of comparison, this skull may well have belonged to a bird with wings of the extent indicated by the humerus already described; and the resemblance of the skull to that of the Albatross would also seem to be confirmatory of the specific collocation of the two specimens. The presence of four small pits or perforations on the only part of the alveolar border which appears to be uninjured, led the author to conjecture that the bird may have been dentigerous; but this seems to be very uncertain.

MINERALOGY.

Amblygonite.—The new mineral species, triploidite, described by Brush and Dana, is shown by them to be isomorphous with wagnerite, and closely related in composition to triplite. These three minerals have respectively the formulæ $(Mn, Fe)\ P_2O_8 + (Mn, Fe)\ (O\ H)_2$, $Mg_2\ P_2O_8 + Mg\ F_2$ and $(Fe, Mn)_2\ P_2\ O_8 + (Fe, Mn)\ F_2$. From a comparison of these formulæ it is argued that the relation between the minerals requires the assumption that the hydroxyl in triploidite must play the same part as the fluorine in the other two. In a paper on the chemical composition of amblygonite, by Samuel L. Penfield (*Amer. Jour. Sc.*, 1879, xviii. 295), the writer endeavours to show that in this mineral also the hydroxyl group is isomorphous with fluorine, and that in chemical composition the original amblygonite does not differ from the American and Montebras varieties, which have been called hebronite. He also shows from the results of his analysis, that a new and more simple formula than any previously accepted must be taken to represent its composition. The specimens examined are three from the Maine localities, from Branchville, Connecticut, two varieties from Montebras, and one from Penig, Saxony. All the specimens gave numbers approaching closely to the ratio 1 : 1 : 1 : 1; hence he proposes the formula $Al_2\ P_2\ O_8 + 2\ R\ (O\ H, F)$, or $\left.\begin{matrix} 3\ Al_2\ P_2\ O_8 \\ 2\ R_2\ P\ O_4 \end{matrix}\right\} + \left\{\begin{matrix} Ae_2\ (O\ H, F) \\ 2\ R\ (O\ H, F) \end{matrix}\right._6$, as the true formula for all varieties of the mineral. Des Cloizeaux, from a difference of optical characters made out by him, has divided the mineral into two species: the original amblygonite, including the specimens for Penig, Saxony, and from Montebras, France; and a second species, for which he proposes the name of montebrasite, the hebronite of Von Kobell, including all the other localities. Owing to the close identity in chemical composition, it seems that a slight variation in optical properties is hardly sufficient ground for dividing the mineral into two species; and it is proposed that the old name of amblygonite should be retained, and that the varieties be included in it.

PHYSICS.

Photometric Researches on Coloured Flames form the subject of an important communication by M. Gouy to the *Annales de Chimie et de Physique*. In an introduction he gives a summary of what has been done in this department since the work of Bouguer, in 1729. His photometer—those of Romford, of Foucault, and of Bunsen, the double refraction instrument of Arago, that by polarised light of Becquerel—are adverted to, all of which are exclusively confined to white light. The first prismatic photometer seems due to M. Gouy, and a very similar instrument to Vierordt. The latter consists of a spectroscope with two continuous slits, the breadth of which can be varied by means of a micrometer screw. The spectra being adjusted to equal intensity, the screw gives the relative breadth of the slits, and, consequently, the comparative brightness of the sources of light. Monsieur Gouy has successfully employed two photometers. The former acts by throwing on the slit

of a spectroscope the image of Babinet's compensator, arranged to give horizontal lines, and causing it to be traversed by two luminous pencils, rectangularly polarized, producing a spectrum marked with horizontal lines. Each pencil gives a separate system of lines, and the dark portions of one being superposed on the bright parts of the other, it is always possible, by varying the intensity of one light by a known quantity to extinguish the lines in one portion of the spectrum. The apparatus is arranged as follows: on the axis of the collimator are placed the following pieces,—An achromatic lens; a Nicol's prism, with its principal axis horizontal; a Babinet's compensator, of peculiar form; an achromatized prism of Iceland spar; a Nicol movable in graduated circle, and a lens. Between the last Nicol and the spar prism, the tube supports a lateral branch at a right angle, containing a total reflection prism and a lens. A flame is placed in front of this side branch, its rays pass through the prism as extraordinary, whereas the opposite occurs with flames placed in front of the movable Nicol. They thus give complementary lines, either series of which can be varied in intensity at will. This instrument had the defect of requiring great intensity of light: and it has been materially improved.

The more recent form is that of a two-prism spectroscope, the second prism of which is movable round the centre of the table, and is attached to the arm bearing the telescope. Before the object-glass of the collimator is a flat mirror covering its upper half. On this are reflected the rays coming from a second collimator, so that if before the two collimator slits are placed two identical sources of homogeneous light, there will be seen the two images coincident in the focus of the observing telescope. There will, therefore, be two semicircles of unequal brilliancy. To equalize them the second collimator has two Nicol's prisms in its axis, one fixed, the other movable: a slit is substituted for the eye-piece of the observing telescope. The coloured flame to be studied is placed before the first-named collimator, and the standard flame before the second.

A method of producing constant coloured flames by means of pulverized saline solutions, forming part of the necessary apparatus, is described at length. Observations follow on sodium flames; on the transparency of coloured flames, for their proper and for heterogeneous radiations; on the density of metallic vapours, and on the reducing or oxydizing portions of solid conical masses of heated gas.

Optical power of Spectroscopes.—Lord Rayleigh notes in the *Philosophical Magazine* that as the power of a telescope is measured by the closeness of the double stars which it can resolve, so the power of a spectroscope ought to be measured by the closeness of the closest double lines in the spectrum which it is competent to resolve. In this sense it is possible for one instrument to be more powerful than a second in one part of the spectrum, while in another part the second instrument is more powerful than the first. The most striking cases of this inversion occur when one instrument is a diffraction- and the other a dispersion-spectroscope. If the instruments are of equal power in the yellow region, the former will be more powerful in the red and the latter in the green. That the resolving power of a prismatic spectroscope of given dispersive material is proportional to the total thickness used, without regard to the number, angles, or setting of the

prisms, is a most important—perhaps the most important—proposition in connexion with this subject. Hitherto, in descriptions of spectroscopes, far too much stress has been laid upon the amount of dispersion produced by the prisms. But this element by itself tells nothing as to the power of an instrument. It is well known that by a sufficiently near approach to a grazing emergence the dispersion of a prism of given thickness may be increased without limit, but there is no corresponding gain in resolving-power. So far as resolving-power is concerned, it is a matter of indifference whether dispersion be effected by the prisms or by the telescope. Two things only are necessary: first, to use a sufficient thickness; secondly, to narrow the beam until it can be received by the pupil of the eye—or rather (since with full aperture the eye is not a perfect instrument), until its width is not more than one third or one fourth of the diameter of the pupil.

Dispersion of Dark Heat-rays, and Measurement of their Wave-lengths, was, according to M. Mouton, first attempted by Herschel, in 1800; it has since been the subject of many researches, which may be divided into two groups. The former, excluding all hypotheses as to the nature of the radiation, endeavours to determine either the position of the heat-maximum, and its dependence on the material and thickness of the prism, or the laws of absorption and transmission proper to the different parts of the spectrum. The latter are so much more important as to need a chronological sketch. In 1818 Berard showed that solar heat is polarized by reflection, and undergoes double refraction. In 1834 Forbes discovered the action of tourmaline and of bundles of mica; Melloni and Biot, the rotation by quartz of the plane of polarization; Wartmann, that by magnetic force. In 1847, Fizeau and Foucault produced interference-phenomena by diffraction; and then added the coincidence in the light spectrum, and the continuation in the ultra-red of the bright and dark bands, obtained either by a crystal plate or by a perpendicular lamina of quartz between two polarizers. The same year there appeared the researches of Knoblauch, Provostaye, and Desains, who established—(1.) That the two heat-pencils emerging from Iceland Spar are completely polarized: one in the principal axis, the other at right angles to it. (2.) That polarized heat follows the laws of light. (3.) That the variations of intensity, after reflection from glass at different incidences, agree with Fresnel's formula. (4.) That there is perfect resemblance between the phenomena of polarized light and heat when reflected from polished metals. They also measured accurately the rotation of the plane of heat-polarization produced by a magnet. In 1850 they studied the polarizing action of glass bundles, and determined the rotatory power of turpentine and sugar solutions for heat. M. Desains, by means of bundles of rock-salt plates, was able to polarize in definite quantity the rays of heat emanating from a source at about 300° Cent., which fail to pass through glass, finding them to be conformable to Fresnel's laws for glass and light. M. Mouton continues what he calls the 'graduation of the heat-spectroscope,' using a modification of M. Fizeau's method: a plate of quartz, cut parallel to the axis, being placed between two parallel Nicol's prisms. The source of heat was a Bourbouze lamp, with a hood of platinum, heated to a white heat by means of gas and compressed air. This was placed in a neighbouring room, communicating with the other apparatus by means of a lens forming an inverted image at

fifty centim. where the slit was situated, the polarizing instruments being between the lens and the slit, and consisting of a double refracting prism of spar with a central extraordinary image for analyser, and a large Nicol for polarizer. The quartz plate was between these. The prisms of quartz were on the coupled principle already employed by MM. Gouy and Thollon (see above). Achromatic lenses were used for collimator and telescope, a linear thermopile being in the principal focus of the latter. Tables of results thus obtained lead to a fine curve, in which abscissæ are wave-lengths, and ordinates, values of $(n'-n)$, or the difference of the indices, which are functions of the wave-lengths and of the substance of the plate.

Harmonic Ratios in the Spectra of Gases have been noted by Professc Johnstone Stoney for three of the hydrogen lines, and others by Soret and Lecoq de Boisbaudran. Mr. Arthur Schaster draws attention in *Nature* to a series which he has found in the Iron-spectrum, of which, however, he has only as yet examined a seventh part. He states them in a tabular form, giving in a first column the corrected wave-length, according to Angström; in a second, a ratio expressed fractionally; in a third, the effect of multiplying the first column by the second; and in a fourth, the nearest observed value of other lines: the last column shows the difference between computed and observed values.

A second table gives a set of iron-lines which can be arranged as Harmonics of a fundamental wave-length of given magnitude. The differences are all small, never reaching an integer, and in one instance sinking to zero. He cannot yet say definitely whether all these coincidences are due to accident. The true law of distribution, however, he thinks not to have been yet found, though harmonic ratios may take a secondary part in it.

A Fresh Experimental Determination of the Velocity of Light has been undertaken by Mr. Nicholson, of the U. S. Navy. He uses, in the main, the same apparatus as was employed by Foucault, namely, a revolving mirror and reflected image. But in Foucault's experiments the deflection was too small to be measured with the required accuracy. It amounted to only a fraction of a millimetre, whereas in these it exceeded 133 millimetres, being about two hundred times that obtained by Foucault. It could be easily increased. The distance between the mirrors was nearly 2000 feet, the radius or distance of the revolving mirror from the slit was about 30 feet, and the speed of the mirror about 256 revolutions per second. The deflection was measured within three or four hundredths of a millimetre in each observation, so that the result is probably correct in this respect to within a ten thousandth. A shed was erected at one end of the line, in one corner of which a heliostat reflected the sun's rays through the slit to the revolving mirror, and thence to the distant mirror. The shed was blackened inside. The revolving mirror consisted of a cast-iron frame, containing, between hardened steel points, an arbor carrying the mirror—a disc of plane glass about $1\frac{1}{4}$ in. diam., silvered on the hither side. A small turbine in a box on the same axis was rotated by the entrance of compressed air striking its vanes, and by the reaction of the same air in escaping. A disc above the mirror served to bring the centre of gravity into the axis of rotation, by means of a series of position-testings. It gave no sound when properly balanced, and needed only occasional lubrication.

The apparatus for measuring deflection consisted of a slide-rest, carrying an adjustible slit, and an achromatic eye-piece, with a single silk fibre in its focus. A piece of plane glass at an angle of 45° is next the eye. The eye-piece was moved till the fibre bisected the deflected image of the slit.

To regulate and measure the speed of rotation, a tuning-fork, bearing on one prong a steel mirror, was employed. This was kept in vibration by means of electricity. It was so placed that the light from the revolving mirror was reflected to the piece of plane glass in the eye-piece and thence into the eye. When fork and revolving mirror are both at rest, the eye sees an image of the revolving mirror; when the fork vibrates this image is drawn out into a band of light. When the mirror begins to revolve this band breaks up into a number of moving images of the mirror; and when finally the mirror makes as many turns as the fork makes vibrations, these images are reduced to one which is stationary. Hence to make the mirror execute a given number of turns, it is only necessary to open the valve, until the images of the revolving mirror come to rest. The electric fork was compared with a standard *Ut* 3 fork, the temperature being noted. The beats were counted for 60″.

The lens was 8 in. in diameter, not achromatic; focus, 150 ft. The stationary mirror was 7 in. in diameter, silvered on the front surface. The distances between the various parts of the apparatus having been determined, the heliostat and distant mirror were adjusted, and the electric fork connected against the standard for 60″. The revolving mirror was then started, and regulated until the image came to rest near the cross-hair. The screw was then turned until the cross-hair bisected the deflected image of the slit. This was repeated until ten observations were taken, and then the temperature was again taken, and the beats noted. Usually five sets of observations were taken morning and evening.

The distance between the two mirrors was taken on an average of five measurements, and found to be 1986·23. The rate of vibration of the standard fork was found by allowing it to trace its record on the lamp-blacked cylinder of a chronoscope, time being given by a sidereal break-circuit chronometer and a Ruhmkorff coil.

The direction of rotation was at first right-handed, and afterwards reversed.

The effects of the vortex of air about the mirror could be found at any speed. To prevent bias in observation, readings were taken by different observers independently of each other.

The result obtained for the velocity of light, *in vacuo*, was 299·828 kilometres per second. Foucault's determination in C.G.S. units being $2{\cdot}98 \times 10._{10}$ or 298 kilometres per second.

ZOOLOGY.

Development of Oysters.—According to the generally received opinion, the eggs of the oyster are fertilized inside the shell of the parent, within the mantle-cavity of which the young are carried until they are provided with

shells of their own; they leave the parent at a tolerably advanced stage of development, and the period of their free existence is very short. Mr. W. K. Brooks states that in the American oysters things go on very differently. Finding that no young oysters were to be met with in the mantle-cavity of the parents, he tried artificial fertilization of ova taken from the ovaries, and was completely successful,—raising millions of young oysters, and tracing them through all their stages of development up to the time when they had acquired all the characteristics which Salensky, Lacaze-Duthiers, Möbius, and others, have figured and described in the young European oyster at the time it leaves its parent. On the other hand, he never found young oysters inside the mantle-cavity of an adult, although from the state of the ovaries the individuals examined were evidently engaged in spawning. Mr. Brooks gives the following statement of the general results of his investigation :—

1. The oyster is practically unisexual; at the breeding season each individual contains either eggs or spermatozoa exclusively.

2. Segmentation of the egg takes place very rapidly.

3. Segmentation is completed in about two hours and gives rise to a gastrula, with ectoderm, endoderm, digestive cavity, and blastopore, and a circlet of cilia or velum. At this stage of development, the embryos crowd to the surface of the water and form a dense layer, less than a quarter of an inch thick.

4. The blastopore closes; the endoderm separates entirely from the ectoderm, and the two valves of the shell are formed, separate from each other, at the edges of the furrow formed by the closure of the blastopore.

5. The digestive cavity enlarges and becomes ciliated, and the mouth pushes in as an invagination of the ectoderm at a point directly opposite that which the blastopore had occupied. The anus makes its appearance close to the mouth.

6. The embryos scatter to various depths, and swim by the action of the cilia of the velum. The shells grow down over the digestive tract and velum, and the embryo assumes a form so similar to various marine lamellibranch embryos which are captured by the dip-net at the surface of the ocean, that it is not possible to identify them as oysters without tracing them from the egg. The oldest ones that he succeeded in rearing in aquaria were exactly like the embryos of *Cardium*, as figured by Lovén.

7. The ovaries of oysters less than one and a half inch in length, and probably not more than one year old, fertilized with seminal fluid from males of the same size, developed normally.

An illustrated report on these highly important and interesting investigations will appear shortly in the Report of the Maryland Fish Commission for 1879.—*Silliman's Journal*, December, 1879.

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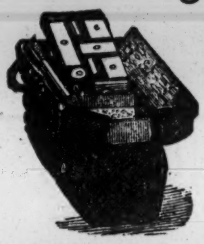

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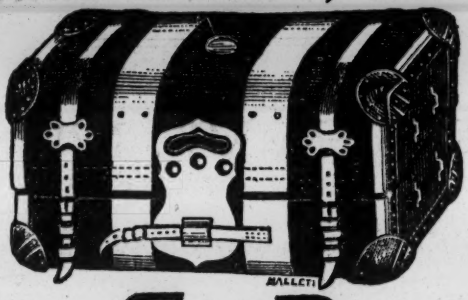

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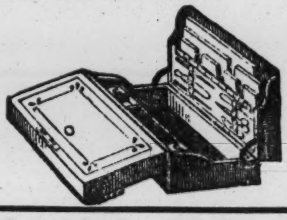

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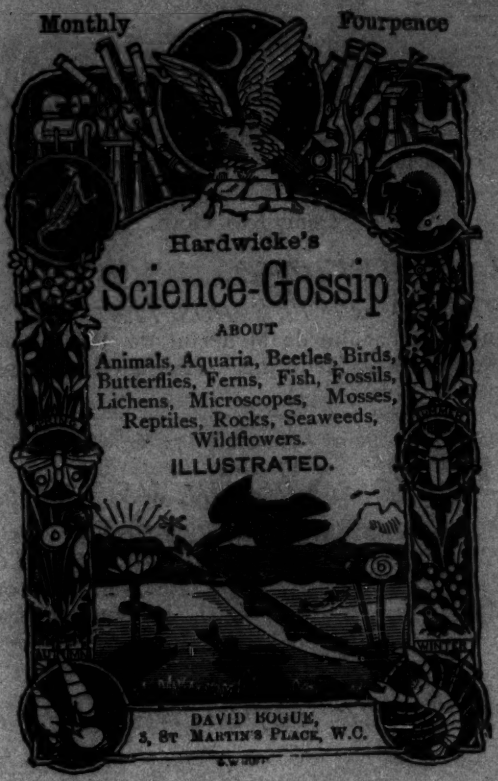

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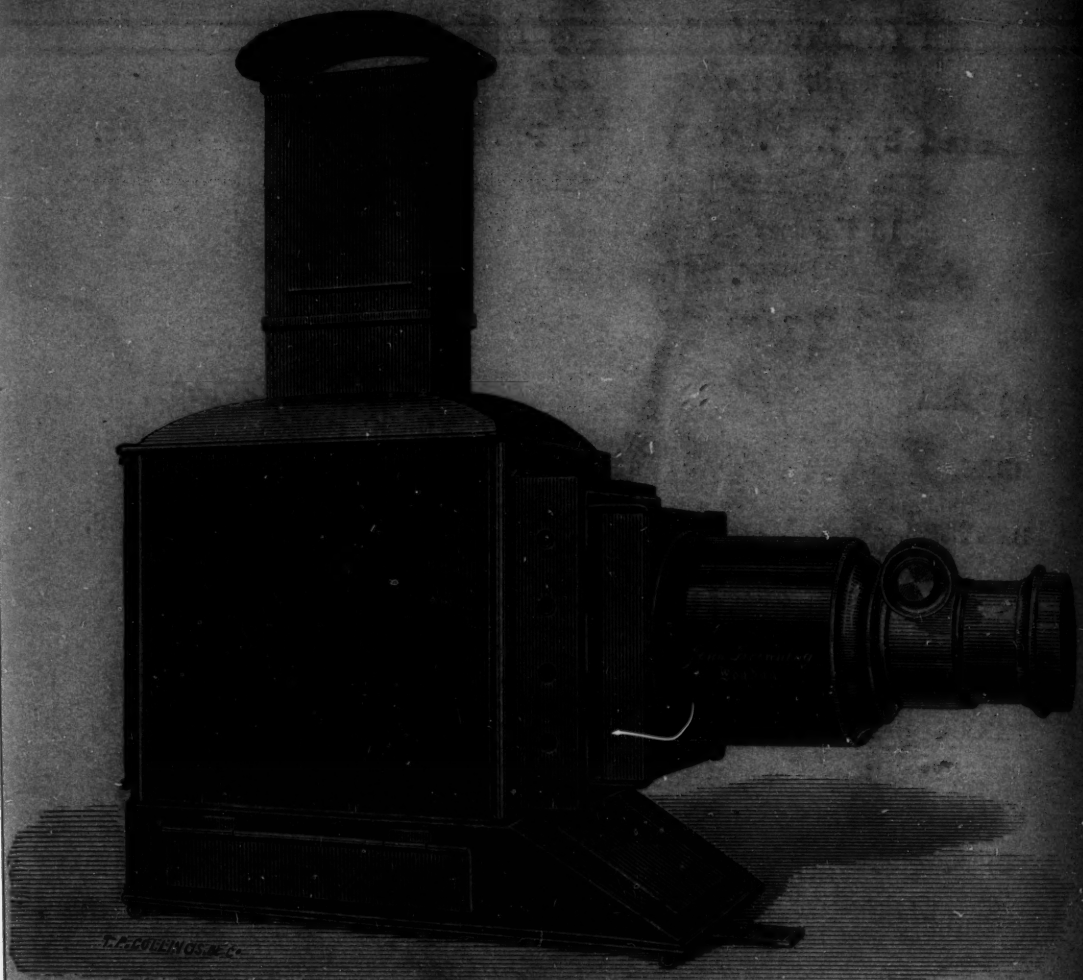

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